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Houses dangle precariously on a newly formed cliff edge following a landslide in Guatemala City. Credit: CONRED.

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Christine W. McEntee, Executive Director/CEO

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Pluto Observers Find Possible Clouds, Remarkably Bright Surface

Spotting shapes and forms in clouds is a fun pastime on Earth, but now scientists can say they've cloud-spotted on one of Earth's distant neighbors: Pluto.

Alan Stern of the Southwest Research Institute (SwRI) in Boulder, Colo., who is principal investigator of the New Horizons mission that buzzed by Pluto in 2015, described several lines of evidence leading the team to suggest that Pluto may sport partly cloudy skies. "If there are clouds, it would mean the weather on Pluto is even more complex than we imagined," Stern said.

He presented the findings on 18 October at the joint American Astronomical Society Division for Planetary Sciences meeting and European Planetary Science Congress in Pasadena, Calif. (see <http://bit.ly/aas-dps>).

Cloudy Dreams

Previous observations established that Pluto hosts a hazy atmosphere. As sunlight strikes the dwarf planet, it spurs formation of the haze, composed of hydrocarbons like acetylene and ethane. The chemicals coagulate into small particles that scatter sunlight, visible as the blue mist captured by the Long Range Reconnaissance Imager (LORRI) aboard New Horizons when the spacecraft flew by Pluto in July 2015.

The haze is extremely thin, however, whereas patches of particles or vapor that sci-

entists would classify as clouds must be discrete, optically thick objects that block the surface, Stern explained.

To hunt for clouds, the New Horizons team looked at data from LORRI and another instrument, the Multispectral Visible Imaging Camera. In high-resolution images, the team spotted several bright smudges at seemingly low altitudes that blocked Pluto's surface. They appeared at Pluto's dawn and dusk, when lower temperatures would allow condensed clouds to form.

"If there are clouds, it would mean the weather on Pluto is even more complex than we imagined."

Furthermore, the researchers spotted these cloud-like features at low altitudes, which agrees with a planetary atmospheric model of cloud formation developed by SwRI scientists in San Antonio, Texas (see <http://bit.ly/atmos-model>).

However, because researchers lack precise altitude data, they can't yet confirm whether

the features lie on Pluto's surface or hang above it, Stern said.

Bright News

The possibility of clouds wasn't the only news unveiled at the meeting by New Horizons researchers. The team had also discovered that parts of Pluto, including its "heart," Sputnik Planitia, are extremely bright, reflecting almost 100% of the light they receive. Nearby dark areas, meanwhile, reflect only 8%–10% of received light.

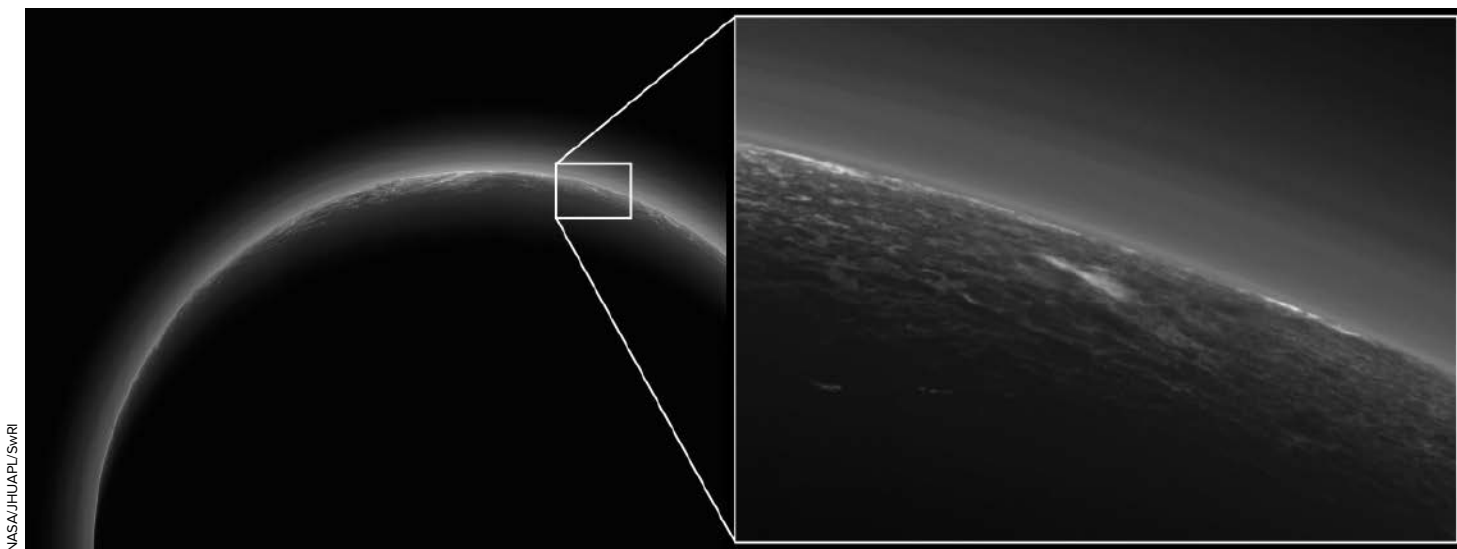
Scientists study the reflectivity of planets and other bodies to learn more about how old the surface topography and textures are, Bonnie Buratti, a principal investigator at NASA's Jet Propulsion Laboratory and coinvestigator on the New Horizons mission, told *Eos*.

"Very bright implies a very young surface," she said, while "darker usually means older."

Pluto's brightest areas almost match the dazzle from Saturn's moon Enceladus, which gets its brightness from active ice volcanoes and geysers. However, Pluto's varied dark and light surface more closely resembles another of Saturn's moons, Iapetus, Buratti said.

The findings have implications for more than just Pluto's history: The brightness of another dwarf planet, Eris, suggests that it could be geologically active, Buratti said. "If we went [to Eris], we wouldn't be surprised to see some type of geologic activity," she said.

By **JoAnna Wendel** (@JoAnnaScience) Staff Writer



This image of Pluto taken shortly after the New Horizons's closest approach in July 2015 shows atmospheric haze backlit by the Sun. The bright smudge in the center of the close-up image may be a low-lying cloud measuring tens of kilometers across.

Ant Populations Destabilize Under Warming



Lauren Nichols

Researchers studied ant species interactions in response to experimentally simulated warming climate. They found that species interactions can shift dramatically, with some species moving into nests permanently and leaving other species without a place to nest.

In the forest, competition for high-quality nesting spots forces ant species to perpetually look for better homes. But a 5-year research endeavor suggests that in a warming climate, ants that thrive at higher temperatures may come out on top at the expense of other ant species' well-being and that of the forest itself.

"This was really a chance to peek under the hood" of how climate change affects the way different species interact with one another, said Sarah Diamond, a biologist at Case Western Reserve University in Cleveland, Ohio, and lead author of a 26 October paper published in *Science Advances* (<http://bit.ly/sci-advancs>).

Diamond noted that many attempts to model how species will respond to climate change ignore indirect consequences of climate change on interactions among species. To fill in this lack of data, she and her colleagues studied how various ant species interacted under artificially induced warming meant to simulate future climate change.

Artificial Warming

The team built enclosures full of ant nest boxes in two university-managed forests—the warmer, more southern Duke Forest in North

Carolina and the cooler, more northern Harvard Forest in Massachusetts—to observe how the ant communities might be affected.

Heating systems with large tubes pumping air throughout each enclosure created warming expected with future climate change. Throughout the experiment, the researchers incrementally raised the temperatures between 1.5°C and 5.5°C above ambient temperatures, in line with forecasts by the Intergovernmental Panel on Climate Change. As controls, some of the experimental enclosures had ambient air pumped in, and some of the enclosures had no air pumped in at all.

The researchers checked once a month on the nest boxes, which attracted more than 60 species of ants. Each time, they noted whether each nest box was occupied and which ant species occupied it. At the end of the experiment, the scientists developed statistical models of the ebb and flow of different ant colonies among the nest boxes.

In a stable ant community, Diamond explained, colonies of various ant species constantly move in and out of nests, with little or no vacancy of nests between residents—this is the equilibrium state. In the warm enclosures, however, the researchers

noticed that the pattern tended to break down as temperatures rose. No longer were species moving to and fro as often as they had been. Instead, those species of ants that thrive at high temperatures, called thermophilic ants, were staying longer and longer in the nest boxes, Diamond said.

This disruption of the normal species interactions reduced the number of nest boxes available for other ant species, Diamond continued. Whether the thermophilic ants displaced other species by physically forcing them out or they simply moved into vacated nests remains unknown.

Ecosystem Consequences

Disrupting this equilibrium state—the ants' constant movement from nest to nest—could affect resiliency of ant populations to environmental disturbance, Diamond said.

In the forest, ant colonies outnumber places to nest, and colonies without nests may perish. In a warming world, heat-loving ants "will hold the high-quality nest sites for longer periods of time," she explained. And if the less thermophilic ants can't find shelter, "they may die off."

"With warming, you start getting one or a few species that dominate the assemblage and become much more persistent," said Jessica Blois, a paleoecologist at the University of California, Merced, who wasn't involved in the new study. "While that's good news for those particular species, the community as a whole is less resilient" because normal movement patterns break down.

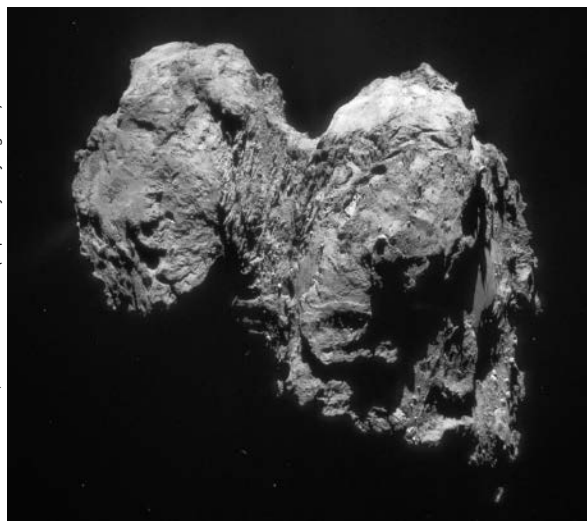
But what does this potential disruption mean for the forest itself? In fact, some of the ant species replaced by the heat-loving species happen to nourish a healthy forest, Diamond said. They disperse seeds and decompose waste. Although the thermophilic ants also serve as waste disposers, Diamond said, they don't disperse seeds the way the less thermophilic ants do.

Ecologist Sarah Gilman of Claremont McKenna College in Claremont, Calif., who also was not part of the ant experiment, said that the forest study adds a "layer of complexity to how we think about species' responses to climate change" and "documented a new consequence of temperature changes on communities."

Diamond and her team have mountains more data to sift through. She said that the group plans to look at responses of the other organisms in each enclosure, including plants, insects, and even spiders.

By **JoAnna Wendel** (@JoAnnaScience), Staff Writer

Cracking Comet: A Window to the Past



ESA/Rosetta/NavCam, CC BY-SA IGO 3.0 (<http://bit.ly/ccbyalg03-0>)

A picture of comet 67P/Churyumov-Gerasimenko, taken by the European Space Agency's Rosetta spacecraft early this year. Scientists observed a crack in the comet's "neck" that grew hundreds of meters over just a couple months.

A crack in the famous comet 67P/Churyumov-Gerasimenko is helping scientists explore mysteries of the solar system's early days.

Back in 2014, about a week after the European Space Agency's Rosetta spacecraft entered orbit around the rubber duck-shaped comet 67P, mission scientists noticed a large crack on

the comet's surface. The crack was seen at the "neck," where one bulbous region meets another.

Rosetta observed the crack as the comet was entering perihelion, its closest approach to the Sun. Onboard cameras observed the crack growing hundreds of meters in length. This event was unusually speedy, said Stubbe Hviid, a planetary scientist at the German Aerospace Center Institute of Planetary Research in Berlin. He discussed the crack in a 17 October presentation at the joint American Astronomical Society Division for Planetary Sciences meeting and European Planetary Science Congress in Pasadena, Calif. (see <http://bit.ly/aas-dps>).

The crack's rapid growth mystified Rosetta scientists: What could crack a comet?

Comet Under Stress

Hviid and his colleagues suspected that stress on the comet might be to blame, so they built stress models of comet 67P. This involved calculating all the different stressors acting on the comet.

As the comet whirls through space, several different stressors act on it: Gravity tries to

mold the body into a sphere, just like it did with Earth and other planets in the solar system, but the comet fights back (this is its tensile strength). Imagine a steel beam poking over the edge of a cliff: Gravity pulls the unsupported end down while the strength of the beam itself resists, Hviid said. In addition, because the comet constantly spins, it's "trying to fly apart" with centrifugal force, he continued.

And because of the comet's odd shape, its "head" is perpetually trying to roll backward onto its "body" as it spins.

Their models revealed that indeed, all that stretching, pulling, and compressing could induce enough stress on the neck of the comet for it to crack, Hviid said.

Comet Origins

Modeling the different stressors on the comet also gave researchers a clue to its origins, Hviid said.

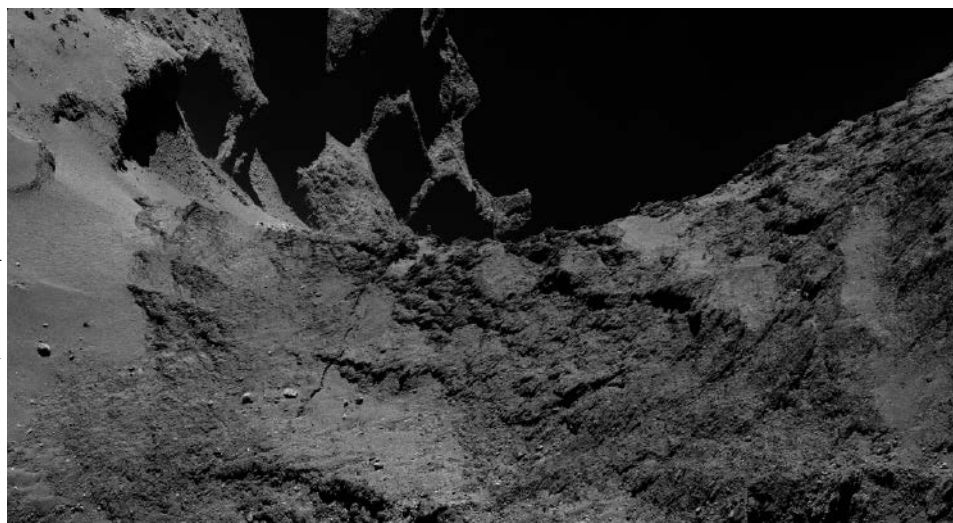
There are two main hypotheses of how comets form from the leftover dust of planet building. One, called the "primordial rubble pile," states that comets come together from the tiny specks of material present in the then newborn solar system and are extremely old.

The other hypothesis, nicknamed the "collisional rubble pile," proposes that chunks of rock first accreted from the dust. Much later, comets formed from those chunks smashing into each other over and over.

Comet 67P's crack lends credence to the former theory that comets are loosely packed aggregates of very primitive, friable material, Hviid said. The crack offers evidence that the comet has little tensile strength compared to the other forces acting on it. That and other characteristics such as the comet's high porosity (meaning that the comet is mostly empty space) result in a very weak structure, like a fragile snowflake floating in space, Hviid said.

Such weak material as 67P contains would have shattered into little bits in the collisional scenario, Hviid suspects. He added that 67P's very existence implies that there aren't as many comets out beyond the solar system as was once thought: If there were as many objects as expected, there'd be a higher chance of collisions, which means comets as fragile as 67P couldn't exist, Hviid said.

The Rosetta mission ended on 30 September of this year with Rosetta's scheduled crash landing. Scientists won't get to see comet 67P up close again, but the crack gives them another clue to the puzzling origin of comets.



A processed image of the crack on comet 67P/Churyumov-Gerasimenko. Researchers found that the crack formed from the stress of the comet bending to and fro while it twirls through space.

By **JoAnna Wendel** (@JoAnnaScience), Staff Writer

Honoring Earth and Space Scientists



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2016 Tinker-Muse Prize for Science and Policy in Antarctica

The Tinker Foundation has honored **Robert DeConto** of the University of Massachusetts Amherst with the 2016 Tinker-Muse Prize for Science and Policy in Antarctica, an international award created to recognize individuals who have contributed important work to the field of Antarctic science.

DeConto is one of the world's leading experts on climate modeling. His integration of geological data and modeling in studying the past and future Antarctic climate, as well as his modeling of sea level rise as a consequence of future ice sheet melt, helped him achieve this honor. The prize includes \$100,000 in recognition for the work he has done to contribute to the understanding of Antarctica and how it responds to climate change. DeConto received his award on 23 August at the Scientific Committee on Antarctic Research 2016 Open Science Conference in Kuala Lumpur, Malaysia.

2016 GSA Medals and Awards

The Geological Society of America (GSA) presented the following medals and awards at its Annual Meeting and Exposition in Denver, Colo., which ran from 25 to 28 September.

Sarah Andrews, geologist and author, received the President's Medal of the Geological Society of America. **John T. Andrews** of the University of Colorado was awarded the Penrose Medal, and **Donald B. Dingwell** of the University of Munich received the Arthur L. Day Medal. The Young Scientist Award, or

Donath Medal, went to **Whitney M. Behr** of the University of Texas at Austin. The GSA Public Service Award was given to **Rex C. Buchanan** of the Kansas Geological Survey. **Kathleen R. Johnson** of the University of California, Irvine, received the Randolph W. "Bill" and Cecile T. Bromery Award for Minorities. The GSA Distinguished Service Award went to **J. Christopher Hepburn** of Boston College and **Lori L. Summa** of the ExxonMobil Upstream Research Company. **Christine A. Regalla** of Boston University received the Doris M. Curtis Outstanding Woman in Science Award. **Marc Robert St-Onge** of the Geological Survey of Canada was awarded the Geologic Mapping Award. **Bor-Ming Jahn** of National Taiwan University was selected as the Honorary Fellow. The John C. Frye Award recognized **Peggy S. Johnson**, **Daniel J. Koning**, **Stacy S. Timmons**, and **Brigitte Felix** for their paper "Geology and Hydrology of Groundwater-Fed Springs and Wetlands at La Cienega, Santa Fe County, New Mexico," published in the *New Mexico Bureau of Geology and Mineral Resources Bulletin*, volume 161.

GSA Division Primary Awards

GSA also announced this year's Division Primary Awards. **Daniel H. Sandweiss** of the University of Maine accepted the Rip Rapp Archaeological Geology Award. **Andy Fisher** of the University of California, Santa Cruz, was selected for the O. E. Meinzer Award. **Robert A. Gastaldo** of Colby College received the Gilbert H. Cady Award. **Alan R. Carroll** of the University of Wisconsin-Madison was given the Israel C. Russell Award. **Donald A. Swan-**

son of the U.S. Geological Survey Hawaiian Volcano Observatory was selected for the Distinguished Geologic Career Award. The E. B. Burwell, Jr., Award recognized **Jeffrey R. Keaton**, **Joseph Wartman**, **Scott Anderson**, **Jean Benoît**, **John deLaChapelle**, **Robert Gilbert**, and **David R. Montgomery** for their report "The 22 March 2014 Oso Landslide, Snohomish County, Washington," supported by the National Science Foundation and published in 2014 by the Geotechnical Extreme Events Reconnaissance Association.

GSA awarded the G. K. Gilbert Award to **M. Darby Dyar** of Mount Holyoke College, and the Outstanding Contributions Award was given to **Betty Adrian** of the U.S. Geological Survey, Denver. The Kirk Bryan Award for Research Excellence honored **Chris Goldfinger**, **C. Hans Nelson**, **Ann E. Morey**, **Joel E. Johnson**, **Jason R. Patton**, **Eugene Karabanov**, **Julia Gutiérrez-Pastor**, **Andrew T. Eriksson**, **Eulàlia Gràcia**, **Gita Dunhill**, **Randolph J. Enkin**, **Audrey Dallimore**, and **Tracy Vallier** for their paper "Turbidite Event History—Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone," *U.S. Geological Survey Professional Paper 1661-F*, published in 2012.

William J. "Bill" Hinze, professor emeritus at Purdue University, received the George P. Woollard Award. **Joshua Villalobos** of El Paso Community College was given the Biggs Award for Excellence in Earth Science Teaching. **Tim Lowenstein** of the State University of New York at Binghamton received the Laurence L. Sloss Award, and the Mary C. Rabbitt History and Philosophy of Geology Award went to **Mott Greene** of the University of Washington. **David Pollard** was chosen for the Career Contribution Award.

GSA Specialized Awards

The Marland Pratt Billings and Katherine Fowler-Billings Research Award honored **Meghan Toft** of the University of Massachusetts Amherst and **Erik Divan** and **Audrey Wheatcroft** of Bates College. **Simon George Scarpetta** of the University of Texas at Austin received the Diversity Award, and **Lauren Collier** of Purdue University was granted the Robert K. Fahnestock Award. The John A. Black Award went to **Lauren Brown** of the University of California, Los Angeles. **Yiduo Liu** of the University of Houston received the Robert D. Hatcher Research Award. The Gretchen L. Blechschmidt Award was given to **Nina Whitney** of Iowa State University, and the John W. Hess Research Grant went to **Isabelle Weisman** of Vanderbilt University. **Hanna Bartram** of the University of Wisconsin-Madison and **Joseph Tulenko** of the University at Buffalo, State University of

New York, both received the John T. Dillon Alaska Research Award. **Hamilton Goodner** of the University of Kansas received the Roscoe G. Jackson II Award.

The Lipman Research Award for student research in volcanology and petrology was given to **Olivia Barbee** of Michigan Technological University, **Zoe Braden** of Queens University, **Matthew Dunlop** of the University of Wyoming, and **Joana Voigt** of the University of Arizona. The John T. and Carol G. McGill Award will support the research of **DeAnna Laurel** of Colorado State University and **Dorothea Lundberg** of the University of Maryland. The John Montagne Award went to **Ny Riavo Voarintsoa** of the University of Georgia, and the Bruce L. "Biff" Reed Scholarship Award was given to **Tess Caswell** of Brown University. **Christine Chen** of the Massachusetts Institute of Technology, **Allison Karp** of Pennsylvania State University, **Andrew Kleinberg** of Florida State University, and **Hadley McIntosh** of the University of Maryland shared the Charles A. and June R. P. Ross Research Award. **Renee Pelletier** of the University of North Carolina at Wilmington received the Alexander Sisson Research Award.

The Parke D. Snavely, Jr., Cascadia Research Award was given to **Rebekah Lee** of Boise State University. **Kirstin Washington** of the University of Southern California received the Harold T. Stearns Fellowship Award. The Alexander and Geraldine Wanek Fund recognized **Benjamin Barnes** of the University of Wisconsin–Madison. The Lauren A. Wright and Bennie W. Troxel Student Research Award will support the research of **Nur Uddin Md. Khaled Chowdhury** of Texas Tech University and **Zachariah Fleming** of the University of Texas at El Paso. The Farouk El-Baz Student Research Grants were awarded to **Christine Chen** of the Massachusetts Institute of Technology for her research project "Reconstructing Past Precipitation Changes from Ancient High-Altitude Lakes in the Central Andes" and to **Elena Favaro** of the University of Calgary for her research project "Initiation of Yardangs in Northwestern Argentina and the Implications for Martian Surface Evolution."

2016 GSA Cole Awards

The Gladys W. Cole Memorial Research Award was given to **Sara L. Rathburn** of Colorado State University for her project "Are All Dams Created Equal? Implications for Carbon Storage." The W. Storrs Cole Memorial Research Award went to **Phoebe A. Cohen** of Williams College for her project "Exploring the Taxonomy and Functional Morphology of the Enigmatic ca. 800 Ma Apatitic Scale Microfossils from Yukon, Canada."



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Upscaling Peatland Science Through Collaborative Big Data

PeatDataHub Launch Meeting

Leeds, United Kingdom, 23–24 May 2016



Andy J. Baird

Measuring the effects of pools on greenhouse gas dynamics on the peatlands of the Royal Society for the Protection of Birds Forsinard Flows reserve in Scotland.

Peatlands' ability to store carbon provides important feedbacks to the climate and biosphere, but few studies provide a genuinely global perspective on peatland processes across space and time. Most monitoring studies are restricted to individual sites or regions; thus, the broad subject of peatland science has much to gain from the analysis of aggregated data from around the world.

PeatDataHub (<http://peatdatahub.net>) is a new international venture among peatland scientists. It seeks to address global-scale questions by developing a database of global monitoring sites to enable the collaborative use of shared data sets.

PeatDataHub was launched during a 2-day workshop last May at the University of Leeds in the United Kingdom. The workshop

brought together scientists who represented a wide range of peatlands in North and South America, Asia, Europe, and Africa. During the meeting, all participants presented their study sites and the focus of their research, demonstrating the incredible richness of data available from peatlands around the world.

The first outcome of the workshop was the definition of the shared principal aim and missions of the project. Some monitoring sites, mainly in the Northern Hemisphere, are able to contribute continuous measurements spanning many years. Participants decided that PeatDataHub should also provide a new framework to enable long-term data sets to be built up by incorporating the many short-term measurements that exist in peatlands in other locations, such as the tropics.

Many peatlands have been degraded by land use, and workshop participants agreed that PeatDataHub provides an important opportunity to influence peatland management practice through engagement with governmental and nongovernmental bodies. Participants also suggested that PeatDataHub should be used to secure new funding for peatland research and monitoring and to help develop new methods for globally collaborative science.

Another outcome of the workshop was an agreement on the measurements that would be included in the first version of the database. Although some projects that bring together large data sets aim to address specific goals, the scope of PeatDataHub is broader; as it develops, it will incorporate a wide range of measured peatland parameters.

Peatland science has much to gain from the analysis of aggregated data from around the world.

To begin the process of building up these data sets, participants decided that a wide range of metadata about sites and methods was essential to the success of the project. They then worked to develop a matrix of sites and available measurements. The matrix currently provides details of more than 40 different parameters across more than 50 peatland study sites.

Using this information, participants devised a set of research questions to address a wide range of topics. These include improving understanding of water table dynamics and aquatic carbon fluxes, developing new evapotranspiration models, and identifying gaps in global peatland data.

Finally, the group agreed on a set of actions to take the project toward its next goal: creating a Web-based application to input and share data. This process is currently under way.

The workshop was funded by the Fund for International Research Collaboration and the River Basin Processes and Management cluster in the School of Geography, University of Leeds.

By **Dylan M. Young** (email: admin@peatdatahub.net), **Paul J. Morris**, and **Joseph Holden**, School of Geography, University of Leeds, Leeds, U.K.

Collaboration to Enhance Coastal Resilience



Win Henderson, FEMA

Hurricane Rita destroyed homes and businesses and severely damaged power and utility systems along the U.S. Gulf Coast. This 3 October 2005 photo shows the extent of the destruction in Holly Beach, a coastal community of 300 residents in Louisiana's Cameron Parish.

The effects of climate change pose numerous threats to communities living near coasts. Rising seas, increased storm frequency and intensity, evolving societal pressures, urbanization, and altered river discharge threaten these communities with inundation, land loss, water quality degradation, disease, and loss of livelihood.

One immediate and urgent duty of scientists is to develop strategies for responding and adapting to likely future scenarios of natural and societal change in response to climate change. Field and remote sensing observations, numerical models, and education must ultimately advance human and ecosystem resilience on global, regional, and local scales.

Agencies charged with planning and risk assessment for coastal communities could benefit from the integration of models from the social and natural sciences. Such collaboration could address risks to human health and safety, as well as risks to such industries as tourism, fisheries, agriculture, and shipping.

A Consortium for Coastal Resilience

Because coastal communities and environments are among the most severely threat-

ened, there is a clear need for a consortium for coastal resilience, consisting of interdisciplinary scientists and a supporting cyberinfrastructure with emphasis on understanding and predicting the future behavior of coastal systems.

The vision is to develop viable long-range resilience programs that enable continually evolving adaptive management strategies. The goals should be to integrate natural and social sciences and to create a cybersupported network of scientists, modelers, engineers, educators, and stakeholders from academia, federal agencies, local and state governments, nongovernmental organizations (NGOs), and the private sector.

Improved resilience of low-income communities in flood-prone areas should be a priority. Model projections and remote sensing can support local governments in assessing resilience, planning for humanitarian assistance, and identifying the most vulnerable communities, environments, and facilities.

For example, models can now predict "street by street" flooding probabilities using detailed topographic data. One immediate objective, which could be accomplished in the near future for specific localities, would be to

combine patterns of social vulnerability (e.g., low incomes or low mobility) with predictions of inundation for various scenarios of sea level rise and storm surges. This would represent a valuable contribution to regional disaster planning.

Data from smartphones, social media, and geographic information systems should enable more effective real-time decisions for guiding the deployment of emergency and rescue resources during future disasters.

Collaboration Strategies

The collaboration strategies and methodologies that we build must be as rigorous as the models and understanding they are designed to facilitate. The ongoing Coastal and Ocean Modeling Testbed (COMT; <http://testbed.sura.org>) is one successful example [Luettich *et al.*, 2013]. COMT has facilitated extensive collaborations among numerous universities and federal agencies. It includes a comprehensive suite of numerical models for predicting natural coastal phenomena, particularly coastal inundation and estuarine and shelf dissolved oxygen dynamics. However, COMT has not yet integrated social sciences or societal processes.

Collaborations should include rigorous observational data and model standards, open-source model code, and effective communication with a hierarchy of scientists and stakeholders. Educating the general public, particularly lower-income and undereducated communities, about hazards and how to respond to them is a critical, but commonly overlooked, facet of outreach to enhance resilience.

The Coastal and Environmental Research Committee (<http://bit.ly/SURA-CERC>) of the Southeastern Universities Research Association (SURA) identified the need for a consortium for coastal resilience. The roughly 100 interdisciplinary participants at SURA-sponsored workshops held in 2014 and 2015 consider the program to be a high priority (more on this below). Attendees agreed that a key role for the consortium should be to provide a virtual environment that connects modelers, other scholars, field empiricists, and educators from various disciplines and institutions worldwide.

A cyberinfrastructure supported by the consortium can provide the playing field for advancing collaboration. The world of "big data" offers ever widening opportunities for collaboration, communication, and informed decision making.

Measuring Our Success

If government officials and the general public are to accept the model predictions coming



Reid Nichols

The extent of flooding during times of spring tides, when the difference between high and low tides is greatest, will increase as sea level rises. On 26 October 2015, attendees at a Southeastern Universities Research Association Coastal Resilience Workshop learned about recurring flooding at the historic Stranahan House in Fort Lauderdale, Fla., during perigean high tides ("king tides," when the Moon is closest to Earth). This wood frame house on the banks of the New River is the oldest surviving structure in Broward County.

from this consortium, program performance metrics will be critical. This principle will guide the progressive evolution of the consortium.

To start with, it will be important to quantify the degree to which participating scien-

important metric, as are improvements in the ability of the scientific community to gain the trust of politicians and officials. To ensure that the consortium is rigorous and objective, an independent expert advisory committee should provide advice, analyses, data stan-

tists and stakeholders agree about strategies for moving forward on the decadal timescale and how best to integrate across disciplines. Measures of effective collaboration may include the production of interdisciplinary, multiauthored publications and disaster response plans.

The extent to which operational agencies adopt, or are influenced by, the collaborative products is another important metric, as are improvements in the ability of the scientific community to gain the trust of politicians and officials. To ensure that the consortium is rigorous and objective, an independent expert advisory committee should provide advice, analyses, data standards, and collaborative integration of coastal resilience science and technology in various coastal regions.

Outlining Future Priorities

To identify the priorities, science requirements, and long-term goals of the consortium, SURA hosted a workshop (<http://bit.ly/modeling-resilience>), Understanding and Modeling Risk and Resilience in Complex Coastal Systems, in Washington, D. C., on 29 and 30 October 2014. The goal was to identify the most critical issues in assessing future risks, vulnerabilities, and resilience of complex coastal systems that involve interdependent social and natural factors. A second

workshop (<http://bit.ly/coastal-resilience>), held 27–29 October 2015 in Broward County, Florida, focused on ways that natural and social scientists can help address the operational needs of local government entities.

A January 2016 white paper (<http://bit.ly/resilience-white-paper>) integrates the outcomes of these two workshops with a literature review of the current thinking on elements of coastal resilience [Wright *et al.*, 2016]. The coastal resilience workshops will continue to promote collaboration and innovation in threatened coastal regions.

Follow-up workshops are expected to focus on the Middle Atlantic Bight and Chesapeake Bay, the northern Gulf of Mexico and Mississippi Delta, and the South Atlantic Bight regions. Scientists, government representatives, NGOs, and stakeholders interested in participating in future workshops are invited to contact Don Wright (wright@sura.org) or Reid Nichols (rnichols@sura.org).

Preparing with Knowledge

In the decades ahead, changes in climate, relative sea level rise, ecosystem structure and function, river discharge, and the intensity and duration of storms and attendant coastal erosion are likely to accelerate the alteration of natural and built coastal environments. New understandings and improved computer models, combined with the advent of a data-intensive society and high-performance computing resources, should enable the scientific community to make giant strides in developing the essential forecasting abilities to prepare for these changes.

But progress will depend on how effectively scientists work together. Only a community that embraces all relevant disciplines and draws from many universities, federal agencies, NGOs, and industries can address the complexity of the coastal realm. Thus, the future must involve the broadest collaboration possible.

References

- Luettich, R. A., Jr., et al. (2013), Introduction to special section on The U.S. IOOS Coastal and Ocean Modeling Testbed, *J. Geophys. Res.*, 118(12), 6319–6328, doi: 10.1002/2013JC008939.
- Wright, L. D., C. R. Nichols, A. G. Cosby, S. Danchuk, C. F. D'Elia, and G. R. Mendez (2016), Trans-disciplinary collaboration to enhance coastal resilience: Envisioning a national community modeling initiative, 30 pp., Southeastern Univ. Res. Assoc., Washington, D. C.

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Bringing Biogeochemistry into the Argo Age

By Kenneth S. Johnson and Hervé Claustre

Plans are under way to integrate and augment a collection of regional programs to form a global biogeochemical monitoring network.

As they drift silently across the world's oceans, the thousands of sensors in the Argo network constantly gather physical data on water conditions as deep as 2 kilometers below the surface. Evolving technology now presents an opportunity for the Argo floats to provide even more information, with the potential to drive a transformative shift in our ability to observe and predict the effect of climate change on ocean ecology, metabolism, and carbon uptake. The new data could also dramatically improve our models of marine resources.

Argo (<http://www.argo.ucsd.edu>), an international program to measure changes in the ocean's heat content and salinity, was launched in 1999 [Roemmich *et al.*, 2015; Riser *et al.*, 2016]. The initial objective of the Argo program was to operate 3200 profiling floats in the ice-free waters from 60°N to 60°S to measure pressure, temperature, and salinity in the upper 2000 meters of the ocean.

R/V Pourquoi Pas deploys a compact, autonomous ARVOR float to join its counterparts in the Argo array. A proposed extension of the Argo program would equip floats around the world to collect biogeochemical data.



Crew members prepare to launch a biogeochemical profiling float from R/V Nathaniel B. Palmer in the Pacific sector of the Southern Ocean.

The program began deploying floats in 2000, and as of October 2016, more than 3700 floats cover most of the world's oceans. These platforms have proven to be robust and cost-effective, and they have gained many more capabilities as technology has evolved. Reflecting this, the Argo program has recently approved planning efforts for extensions that include operations at depths below 2000 meters, operations in ice-covered waters at higher latitudes, and focused operations in equatorial waters and western boundary currents.

Here we report on the activities under way to prepare for an Argo extension to include biogeochemical observations. If approved, Biogeochemical-Argo would be an extension of the Argo array that aims to equip floats across the entire network with a standard set of biogeochemical sensors.

These sensors would provide real-time data for pH, oxygen, nitrate, chlorophyll, suspended particles, and measurements of the amount of the penetrating sunlight (downwelling irradiance) that drives photosynthesis. Data from these sensors would be accessible to the public.

Biogeochemical-Argo Array

A global Biogeochemical-Argo array would enable direct observation of the seasonal- to decadal-scale variability in net community production (the rate at which life-forms capture and store chemical energy as biomass), the supply of essential plant nutrients transported from deep waters to the sunlit surface layer, ocean acidification, hypoxia (low oxygen levels), and ocean uptake of carbon dioxide. Bio-optical sensors would supplement satellite observations of the ocean's color by providing measurements of chlorophyll, light, and light scattering deep into the ocean interior throughout the year, in cloud- and ice-covered areas, or during the dark of polar winter.

Development of a global Biogeochemical-Argo array is proceeding on two tracks.

First, a set of regional- and smaller-scale programs is in operation around the world. These programs have already equipped almost 10% of the Argo array with biogeochemical sensors. Although these programs are sponsored by various organizations and operate independently, they must make their data available to the Argo community and process their data according to Argo standards.

The second track involves the planning needed to scale the various regional projects into an integrated, global program. Scientists from eight countries met in January to formalize the

planning process. They produced a document outlining the system requirements, and the science ministers from the Group of Seven (G7) nations endorsed the concept last May. This effort includes a variety of data analyses to determine the appropriate array size.

Regional Biogeochemical Arrays

The regional arrays provide a sampling of ocean conditions around the world that is designed to produce an integrated data set that can be used to address questions related to physical-biogeochemical coupling in eddies, phytoplankton phenology (cyclic and seasonal phenomena), nutrient supply, and climate effects on ocean carbon cycling in selected regions. Some of these arrays include

- the Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM) project
- the Remotely Sensed Biogeochemical Cycles in the Ocean (remOcean) project in the North Atlantic sub-polar gyre
- the Novel Argo Ocean Observing System in the Mediterranean Sea (NAOS)
- the Integrated Physical-Biogeochemical Ocean

Observation Experiment (INBOX) in the Kuroshio region of the North Pacific

- the Australia-India Joint Indian Ocean Bio-Argo Project (IO Bio-ARGO)

Smaller-scale deployments have occurred at a variety of locations, particularly such well-studied sites as the University of Hawai'i at Mānoa's Hawaii Ocean Time-series (HOT) station, where long biogeochemical records from floats (Figure 1) can be calibrated against shipboard measurements. The number of vertical oxygen profiles collected by all of these floats, reaching depths near 1000 meters, now greatly exceeds the number that ships collect each year in the open ocean [Johnson *et al.*, 2015].

These regional programs and such international collaborations as the Scientific Committee on Oceanic Research

(SCOR) Working Group 142 (<http://bit.ly/SCOR-WG142>) have laid the foundation for a global observing system by validating sensor operation and developing software tools. The regional programs are also building the expertise needed to operate a global network that interacts with other components of the global ocean observing system, including satellites [Claustre *et al.*, 2011], ship-board programs like the international Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP; <http://www.go-ship.org>), and various time series stations.

Data Analysis and Management

The regional programs and international collaborations are enabling regional- to global-scale analyses of data. Using oxygen sensors on more than 100 profiling floats distributed globally, scientists have assessed, for the first time, oxygen consumption rates in the mesopelagic zone beneath the ocean's surface, where too little sunlight penetrates to support photosynthesis, and the carbon export that fuels this respiration [Hennon *et al.*, 2016].

Bio-optical measurements of chlorophyll from these floats show no significant bias with satellite remote sensing products [Xing *et al.*, 2011]. These measurements enable scientists to study many fundamental aspects of phytoplankton ecology [Boss and Behrenfeld, 2010]. Combining bio-optical measurements from floats and satellites also enables scientists to create a three-dimensional reconstruction of the particulate organic carbon distribution [Sautède *et al.*, 2016].

Nitrate sensors on the floats [Johnson *et al.*, 2013] enable researchers to study the bottom-up influence of nutrient supplies on ecosystems. For example, the NAOS array of profiling floats in the Mediterranean Sea, equipped with nitrate sensors, shows seasonal variability that was previously unobservable [Pasqueron de Fommervault *et al.*, 2015].

Profiling floats deployed at the HOT station (Figure 1) have produced pH readings at the sea surface over the course of several years that agree with the ship-board observations to 0.004 ± 0.007 pH unit [Johnson *et al.*, 2016]. This precision exceeds the Global Ocean Acidification

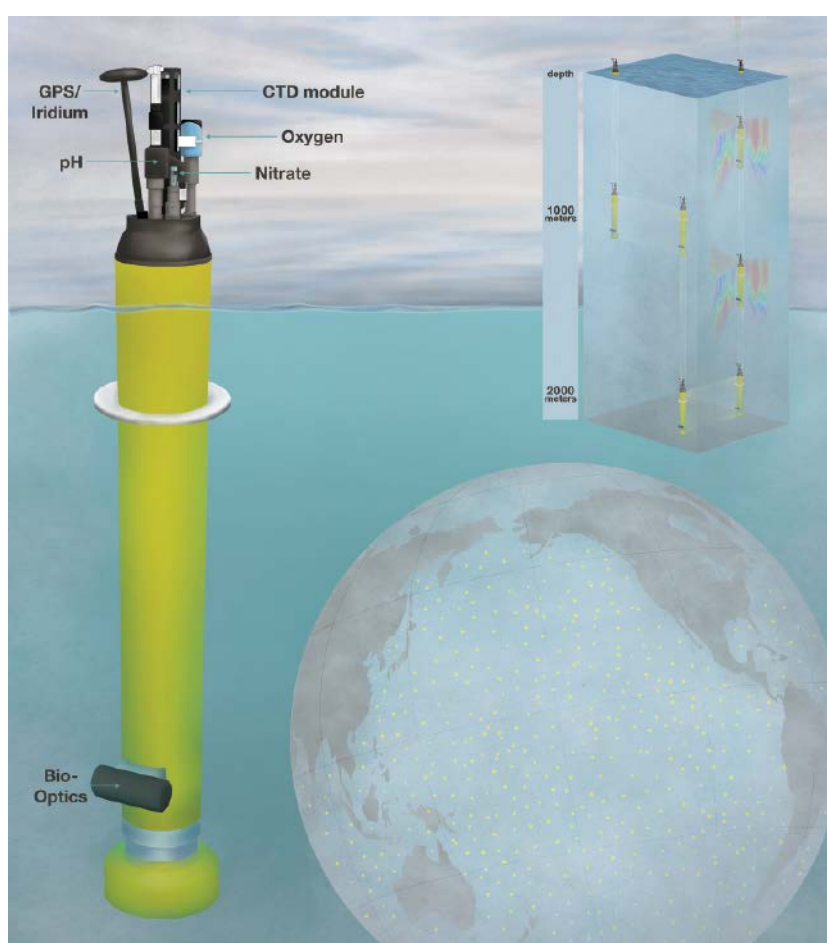
Observing Network's requirements for pH measurements (see <http://bit.ly/GOA-ON-requirements>).

In parallel with these pilot projects, the community has begun to develop shared data management procedures. The successful data management system of the existing Argo program serves as a basis for adapting the system for biogeochemical parameters. The Argo Data Management Team (<http://www.argodatamgt.org>) has developed a parallel file structure for the core temperature, salinity, and pressure data and for associated biogeochemical data. Annual meetings of the Argo Data Management Team and members of the regional biogeochemical float programs are optimizing this new data management and distribution system.

Global Planning

The success of these regional projects has led to the second track of the project: preliminary planning for the transition to a global-scale Biogeochemical-Argo program. Plan-

Biogeochemical-Argo would equip floats across the entire Argo network with a standard set of biogeochemical sensors.



Kelly Lance, Monterey Bay Aquarium Research Institute

Drawing of a profiling float equipped with biogeochemical sensors. (CTD is conductivity, temperature, and depth.) Insets show (top) a typical float mission as it descends to 2000 meters and (bottom) the global array at the proposed density.

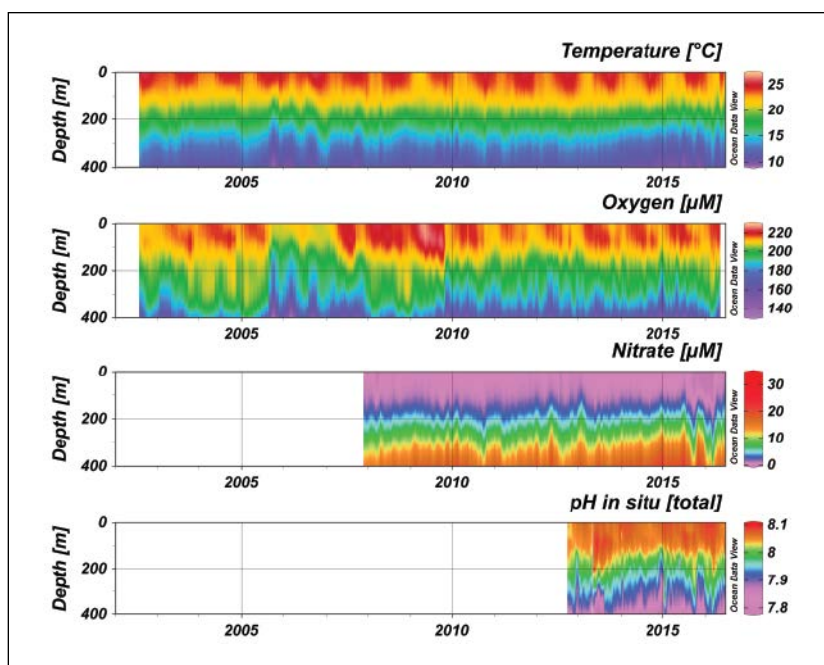


Fig. 1. Temperature, oxygen, nitrate, and pH data measured from profiling floats deployed at the HOT station ALOHA since 2002. Adapted from data reported by Riser and Johnson [2008] and Johnson et al. [2010, 2013, 2016].

ning includes several OceanObs'09 reports [Gruber et al., 2010; Claustre et al., 2010] and a U.S. Ocean Carbon and Biogeochemistry Scoping Workshop [Johnson et al., 2009].

To formalize planning for Biogeochemical-Argo, scientists gathered for a meeting on 11–13 January 2016 in Villefranche-sur-Mer, France, with attendees from Australia, Canada, China, Japan, France, Germany, the United Kingdom, and the United States. On the basis of observing system simulation experiments and analyses of global ocean data sets presented at the meeting, attendees concluded that an array of about 1000 biogeochemical profiling floats would provide the needed resolution to greatly improve our understanding of biogeochemical processes on a global scale and would reduce the uncertainties of major ocean carbon fluxes. Such an array would significantly improve marine resource models.

The science ministers of the G7 nations have indicated their support for this effort. They issued a communiqué (see <http://bit.ly/Tsukuba-Communique>) and an appendix (Attachment 2) after their 15–17 May 2016 meeting in Tsukuba, Japan, that endorses the development of a global ocean biogeochemical observing system through the Argo network.

Costs

At the January planning meeting in Villefranche, attendees formulated estimates of the costs of implementing and maintaining the proposed additions to the Argo network.

A Biogeochemical-Argo float lasts for about 4 years, so this system would require the annual procurement and deployment of 250 new floats to sustain it. The lifetime cost for a Biogeochemical-Argo float, including capital expense, calibration, data management, and data trans-

mission, is about \$100,000. A global Biogeochemical-Argo system would thus cost nearly \$25,000,000 annually [National Research Council, 2015].

In the present Argo paradigm, the United States provides half of the profiling floats in the array while the European Union (EU) and Australia/Asia/Canada share most of the remaining half. If this continued, the U.S. cost for the Biogeochemical-Argo system would be about \$12,500,000 annually, and the EU and Australia/Asia/Canada would each pay about \$6,250,000.

By way of comparison, the annual cost of the proposed U.S. share is about one quarter of the annual cost of either the U.S. Ocean Drilling Program or the U.S. Ocean Observatories Initiative, and it is similar to the annual operating cost of one Global Class research vessel in the U.S. fleet.

This presumes that float deployments can be carried out on research cruises already

planned, particularly the international GO-SHIP program, which provides essential validation data.

A New Age for Ocean Biogeochemistry

A global Biogeochemical-Argo system would enable a transformation in our understanding of ocean biogeochemistry, climate interactions, and marine resources. It would provide data from regions and under conditions not accessible to satellites, and the global coverage would provide an integrated picture of the systems that drive the world's ocean ecosystems.

The summary document (<http://bit.ly/biogeo-Argo-plan>) from the Villefranche meeting, “The Rationale, Design and Implementation Plan for Biogeochemical-Argo,” is available from the program website (<http://www>

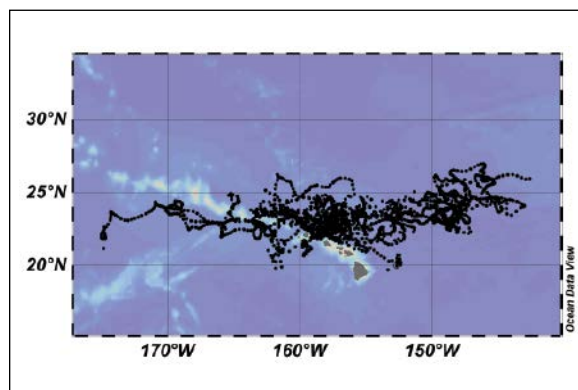
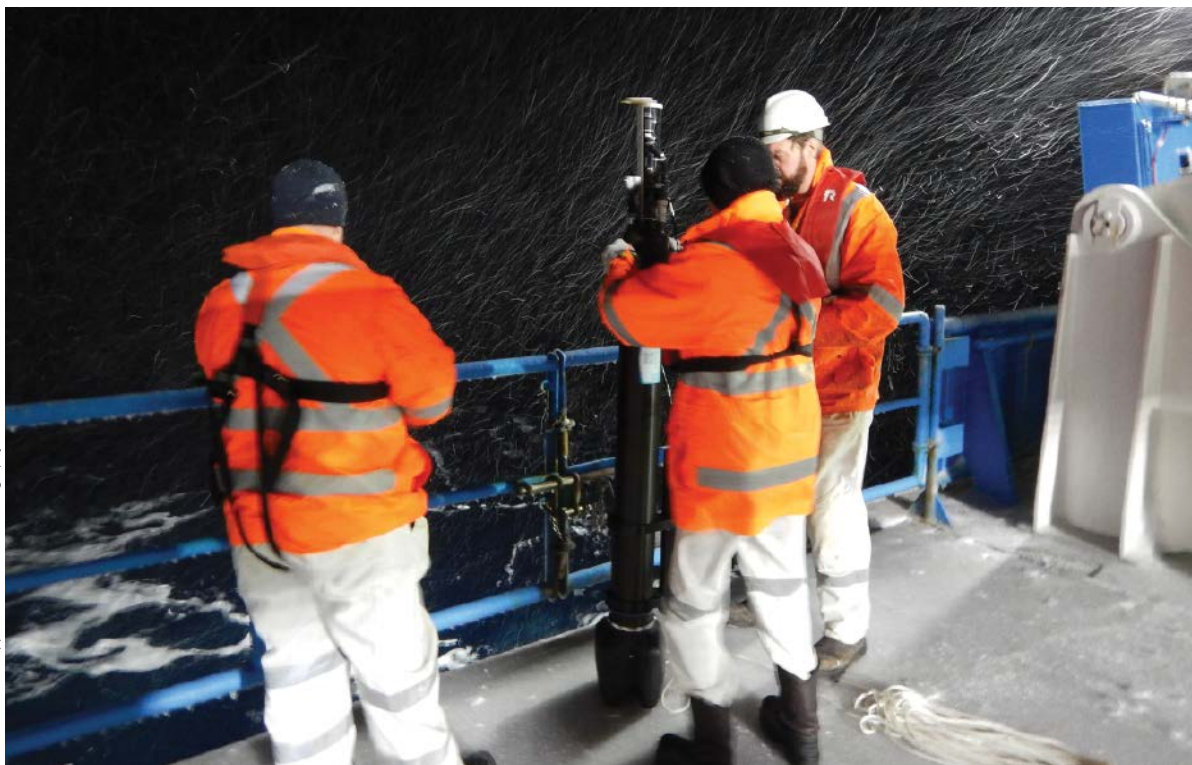


Fig. 2. Profile locations as the floats disperse from HOT to collect the data shown in Figure 1.



Three crew members prepare a profiling float for launch near the ice edge in the Southern Ocean. In an international collaboration, the float is being deployed for the U.S. Southern Ocean Carbon and Climate Observations and Modeling program from the Australian R/V Investigator.

.biogeochemical-argo.org), and we encourage the public to contact us with their comments at johnson@mbari.org or clautre@obs-vlfr.fr.

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References

- Boss, E., and M. Behrenfeld (2010), In situ evaluation of the initiation of the North Atlantic phytoplankton bloom, *Geophys. Res. Lett.*, **37**, L18603, doi:10.1029/2010GL044174.
- Claustre, H., et al. (2010), Guidelines towards an integrated ocean observation system for ecosystems and biogeochemical cycles, in *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society*, vol. 1, edited by J. Hall, D. E. Harrison, and D. Stammer, Eur. Space Agency, Paris, doi:10.5270/OceanObs09.pp.14.
- Claustre, H., et al. (Eds.) (2011), Bio-optical sensors on Argo floats, *IOGC Rep. 11*, Int. Ocean-Colour Coord. Group, Dartmouth, N. S., Canada.
- Gruber, N., et al. (2010), Towards an integrated observing system for ocean carbon and biogeochemistry at a time of change, in *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society*, vol. 1, edited by J. Hall, D. E. Harrison, and D. Stammer, Eur. Space Agency, Paris, doi:10.5270/OceanObs09.pp.18.
- Hennon, T. D., S. C. Riser, and S. Mecking (2016), Profiling float-based observations of net respiration beneath the mixed layer, *Global Biogeochem. Cycles*, **30**, 920–932, doi:10.1002/2016GB005380.

- Johnson, K. S., W. M. Berelson, E. S. Boss, Z. Chase, H. Claustre, S. R. Emerson, N. Gruber, A. Körtzinger, M. J. Perry, and S. C. Riser (2009), Observing biogeochemical cycles at global scales with profiling floats and gliders: Prospects for a global array, *Oceanography*, **22**(3), 216–225.

- Johnson, K. S., S. C. Riser, and D. M. Karl (2010), Nitrate supply from deep to near-surface waters of the North Pacific subtropical gyre, *Nature*, **465**, 1062–1065, doi:10.1038/nature09170.

- Johnson, K. S., L. J. Coletti, H. W. Jannasch, C. M. Sakamoto, D. Swift, and S. C. Riser (2013), Long-term nitrate measurements in the ocean using the In Situ Ultraviolet Spectrophotometer: Sensor integration into the Apex profiling float, *J. Atmos. Oceanic Technol.*, **30**(8), 1854–1866, doi:10.1175/JTECH-D-12-00221.1.

- Johnson, K. S., J. N. Plant, S. C. Riser, and D. Gilbert (2015), Air oxygen calibration of oxygen optodes on a profiling float array, *J. Atmos. Oceanic Technol.*, **32**(11), 2160–2172, doi:10.1175/JTECH-D-15-01011.

- Johnson, K. S., H. W. Jannasch, L. J. Coletti, V. A. Elrod, T. R. Martz, Y. Takeshita, R. J. Carlson, and J. G. Connery (2016), Deep-Sea DuraFET: A pressure tolerant pH sensor designed for global sensor networks, *Anal. Chem.*, **88**, 3249–3256, doi:10.1021/acs.analchem.5b04653.

- National Research Council (2015), *Sea Change: 2015–2025 Decadal Survey of Ocean Sciences*, Natl. Acad. Press, Washington, D. C., doi:10.17226/21655.

- Pasqueron de Fommervault, O., et al. (2015), Seasonal variability of nutrient concentrations in the Mediterranean Sea: Contribution of Bio-Argo floats, *J. Geophys. Res. Oceans*, **120**, 8528–8550, doi:10.1002/2015JC011103.

- Riser, S. C., and K. S. Johnson (2008), Net production of oxygen in the subtropical ocean, *Nature*, **451**, 323–325, doi:10.1038/nature06441.

- Riser, S., et al. (2016), Fifteen years of ocean observations with the global Argo array, *Nat. Clim. Change*, **6**, 145–153, doi:10.1038/nclimate2872.

- Roemmich, D., J. Church, J. Gilson, D. Monselesan, P. Sutton, and S. Wijffels (2015), Unabated planetary warming and its ocean structure since 2006, *Nat. Clim. Change*, **5**, 240–245, doi:10.1038/nclimate2513.

- Sauzède, R., H. Claustre, J. Uitz, C. Jamet, G. Dall'Olmo, F. D'Ortenzio, B. Gentili, A. Poteau, and C. Schmechtig (2016), A neural network-based method for merging ocean color and Argo data to extend surface bio-optical properties to depth: Retrieval of the particulate backscattering coefficient, *J. Geophys. Res. Oceans*, **121**, 2552–2571, doi:10.1002/2015JC011408.

- Xing, X., A. Morel, H. Claustre, D. Antoine, F. D'Ortenzio, A. Poteau, and A. Mignot (2011), Combined processing and mutual interpretation of radiometry and fluorimetry from autonomous profiling Bio-Argo floats: Chlorophyll *a* retrieval, *J. Geophys. Res. Oceans*, **116**, C06020, doi:10.1029/2010JC006899.

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An Early Warning System for Landslide Danger

By Ari J. Posner
and Konstantine P. Georgakakos

Landslides are one of the costliest and deadliest natural phenomena in mountainous regions. Between 2007 and 2015, 7000 rainfall-triggered landslides around the world killed more than 25,000 according to NASA's Global Landslide Catalog (<http://bit.ly/GLCatalog>). The U.S. Geological Survey estimates that costs from these events could reach \$4 billion or more each year (see <http://bit.ly/Landslide-FAQ>).

Landslides are also one of the most difficult natural disasters to predict because the factors that affect slope stability vary dramatically in both space and time. However, dramatic advances in precipitation estimation, high-resolution imagery, and elevation maps are advancing our ability to predict the threat of rainfall-triggered landslides

After a 2012 landslide in Finca Loma Linda, Guatemala, 46 people were forced to evacuate to an emergency shelter in a community hall. The Hydrologic Research Center, a nonprofit research corporation, is developing a landslide hazard threat assessment for Central America.

in real time. Applying these advances to landslide prediction, especially in developing areas of the world, could save countless lives and direct resources to where they are most needed for landslide prevention and recovery.

To help with efforts to develop a prototype for landslide prediction, the Hydrologic Research Center (HRC; <http://www.hrcwater.org>), a nonprofit research corporation, set out to develop a landslide hazard threat assessment for Central America. We focused on the nations of Central America because of the strong regional partnerships already in place there, as well as the availability of relevant data.

Our approach involves including landslide threats in flash flood guidance threat assessments. We got our first opportunity to validate our threat assessment system in October 2015, when a major landslide occurred in an area of Guatemala that we had flagged as an area of very high risk during that time period.

Aims of the Assessment

Predicting the threat of rain-induced landslides is imperative. A recent review shows that 90% of all recorded landslides in Latin America and the Caribbean were triggered by heavy rainfall, which increases the amount of moisture in the soil [Sepulveda and Petley, 2015]. This review found that between 2004 and 2013, about 2730 people died in 128 landslides in Central America. Of the landslides that were triggered by rainfall, 15% were associated with named tropical storm events. Only 4% of landslides were earthquake induced, and the remaining 6% were associated with construction or volcanic activity.

To help mitigate this high level of risk, our assessment has three main goals:

- develop a calibrated and validated spatial and temporal representation of real-time landslide hazard threat assessments for regional emergency management services

- train national meteorological and hydrologic services in how to understand and interpret landslide hazard threat assessment products

- bring partners together to discuss landslide issues and identify opportunities where we can develop such tools as planning, education, and warning systems to reduce the impact of landslide events

Central American Regional Partnerships

Landslide threat assessments across Central America accelerated after October 1998, when Hurricane Mitch dropped record-breaking amounts of rain on Honduras, Guatemala, and Nicaragua—more than 900 millimeters in some regions of Honduras. The resulting floods made Mitch the second-deadliest Atlantic hurricane in history, with nearly 11,000 fatalities and a similar number of people reported missing. The U.S. Army Corps of Engineers estimated that the landslides that followed damaged 70% of the road network in Honduras, and a conservative estimate by the U.S. Geological Survey (USGS) places the number of Honduran landslide fatalities at nearly 1000.

Fig. 1. We verified landslide reports in El Salvador's Ministry of Natural Resources and the Environment (MARN) database using all available imagery, including Google Earth™, using geographic information system (GIS) software. Pictured here is a landslide (deslizamiento) we verified, triggered by an earthquake near the town of Las Colinas, El Salvador, in January 2001. The red polygon shows the steep escarpment where the landslide originated, and the map pin shows the location reported in the database, which corresponds to an area of property damage. GoogleEarth™ imagery ©Google Inc. and DigitalGlobe. Used with permission. Google and the Google logo are registered trademarks of Google Inc.





Residents begin clearing away debris from the Old Town section of San Miguel Escobar, Guatemala, after Hurricane Agatha unleashed a landslide there in 2010.

USGS produced a detailed report (see <http://on.doi.gov/2g04c3k>) of landslides in the affected areas, as well as a discussion (see <http://bit.ly/Landslide-discussion>) of these landslides. A subsequent effort, led by the Norwegian Geotechnical Institute, organized annual landslide workshops from 2003 to 2008. These workshops focused on training national hydrologic and meteorological services and disaster management agencies to inventory landslides, map hazards, and assess threats. Recently, the Japan International Cooperation Agency began working in Honduras to help develop landslide hazard threat assessments.

The Science of Assessing Landslide Hazard Threats

Predicting the temporal and spatial occurrence of rainfall-triggered shallow landslides represents an important scientific and practical issue. Intrinsic factors (topography, geology, soil, and engineering properties) and extrinsic factors (rainfall, land cover, fire, glacier outbursts, earthquakes, and volcanoes) control slope stability and landslide triggering. The likelihood of a landslide is also affected by the nonuniform nature of the structural forces that hold a slope together and the physical mechanisms that trigger the landslide.

Landslide hazard threat assessments are segregated in both space and time—each assessment is separate unto itself. Spatial threat assessments (susceptibility maps) are derived in one of two ways: using spatially distributed parameters (e.g., slope, geology, precipitation totals) to assign a weight to individual pixels in a grid or using a database of existing landslides, along

with spatially distributed parameters, to derive weights using a variety of statistical methods.

Wanted: Protocols for Tracking Landslides

Although using a database of known landslide events is ideal, potential biases in existing landslide databases pose severe limitations. For example, some databases account only for landslides that affect human life, property, or infrastructure. The lack of a common data collection protocol (size, depth, runout length, etc.) means that various databases record different accounts of the same landslide. Therefore, developing protocols for these landslide databases is critical for efforts in understanding landslide distribution and associations with landscape characteristics.

During our communications with other national meteorological and hydrologic services and emergency management agencies from all over Central America, this need became starkly clear: Most systems had no well-defined protocol for landslide data collection.

For example, we learned that El Salvador's Ministry of Natural Resources and the Environment has a detailed database of landslides that includes event timing and site visit reports. We verified the landslides using online imagery and a review of the site visit reports. Events were often recorded as locations where populations were affected, rather than as the landslide source (Figure 1). We performed a thorough quality control assessment of the database (Figure 2) that highlighted the need for the development of a systematic data collection and storage protocol.

So we're tackling these needs: Current project goals include developing the

The team has a new push: incorporate a landslide hazard threat assessment into our flash flood guidance systems.

required data collection protocols and storage, familiarizing partners with the flash flood guidance system, and introducing the new landslide hazard threat assessment.

Rainfall and Soil Moisture Add Complexity

Even if we do have a detailed database, identifying slopes with high landslide threat levels is difficult, and predicting when rainfall-triggered landslides will occur is even more difficult and fraught with uncertainty. At the hillslope scale, a variety of tools are available, including sophisticated monitoring systems and high-resolution modeling, which are infeasible at the regional scale.

In lieu of monitoring each landslide-prone location, regional real-time landslide hazard threat assessments generally rely exclusively on rainfall thresholds. These hazard assessments most commonly use precipitation conditions observed during a sample of landslide events to construct a precipitation intensity-duration curve.

This method has been adapted and used in many regions; however, in most cases landslide hazard threat assessments based solely on precipitation intensity and duration are insufficient because soil moisture conditions play a crucial role. We do not recommend using estimates of precipitation that precedes a landslide in place of soil wetness conditions; the nonuniformity of geophysical and climatic characteristics weakens the correlation between

Both the static susceptibility map and the real-time landslide hazard threat assessment identified El Cambray as having the highest possible threat levels.

antecedent precipitation and actual soil moisture observations [Baum and Godt, 2009].

Soil moisture estimates can be achieved through in situ measurement, remote sensing, and hydrologic model simulations. When all these sources are available, their integration may provide reliable estimates of soil moisture at the scales required for landslide hazard threat assessment operational warning systems. However, few locations maintain sustained in situ soil moisture measurements. Remote sensing of soil moisture has come a long way, but serious limitations remain, particularly in mountainous regions with dense vegetation.

Therefore, in most cases, real-time soil moisture levels can most readily be estimated using hydrologic model simulations. This is the approach we use.

Including a Landslide Hazard Assessment in Flash Flood Guidance Systems

In recent years, regional operational flash flood guidance systems have been implemented worldwide. These systems use real-time remotely sensed data to estimate precipitation over regional scales at a high resolution (4 kilometers \times 4 kilometers).

The HRC has invested more than a decade in the development of its flash flood guidance systems [Georgakakos et al., 2013]. National meteorological and hydrologic services use the system across Central America to predict flash flooding.

As a result of conversations with national meteorological and hydrologic services and emergency management systems, the HRC team has a new push: incorporate a landslide hazard threat assessment into our flash flood guidance systems. To do this, HRC systems merge precipitation data from several satellites, radars, and rain gauges and then use them as inputs in a high-resolution model that accounts for soil moisture.

These simulations produce estimates of soil water deficit levels in various soil zones and estimate the propensity of small basins (about 160 square kilometers) for flash flooding [Georgakakos et al., 2013]. These operational regional systems provide hourly estimates of depth-integrated soil moisture for two layers in the soil for each small basin.

In 2010, Hurricane Agatha triggered a landslide on the northern outskirts of Guatemala City that destroyed a house, killing 11 people inside and burying a nearby car. The Hydrologic Research Center, a nonprofit research corporation, is developing a landslide hazard threat assessment for Central America.



Globovision

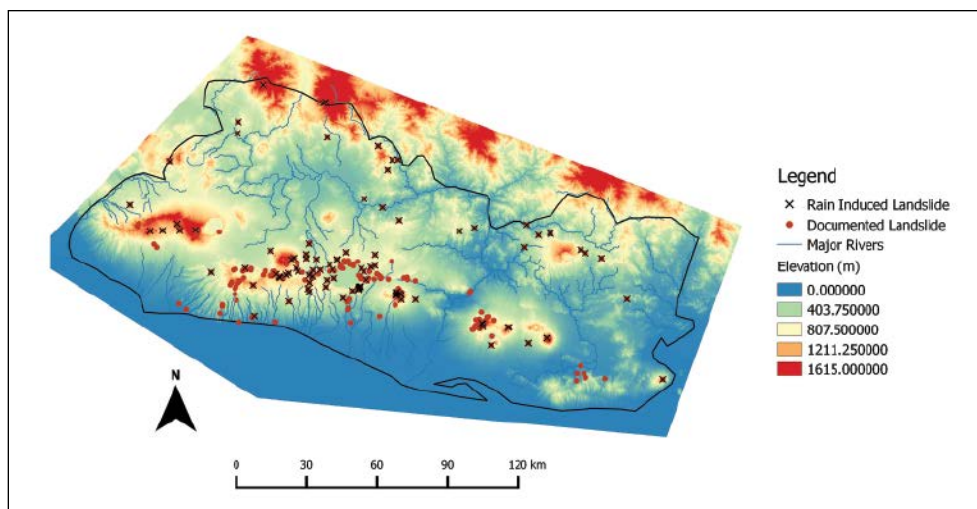


Fig. 2. The El Salvador MARN provided a spatial and temporal database of landslide events dating from 1990 to the Hydrologic Research Center, which we validated using quality control procedures. Shown here is a map of documented Salvadoran landslides, indicating which ones were induced by rain.

Assessments Based on Observation

Our project introduces a novel approach for landslide hazard threat assessment at the regional scale using a phenomenological model. In other words, the model is based on observations rather than derived from theory.

The approach is suitable for use in conjunction with the operational flash flood guidance systems and with landslide susceptibility mapping [Posner and Georgakakos, 2015a, 2015b]. The landslide susceptibility mapping helps us locate where landslides are most likely to occur, and the flash flood guidance system helps predict the timing of these landslides [Posner and Georgakakos, 2015a]. We can conduct real-time assessment of the probability that a landslide will occur through a paired precipitation and soil moisture threshold for individual small basins [Posner and Georgakakos, 2015b].

Does the Assessment Work?

On 1 October 2015, we got our first opportunity to validate the system after its development. Heavy rains triggered a landslide in the community of El Cambray, Guatemala, killing at least 280 people and leaving some parts of the village under 15 meters of earth and debris.

Initial findings are encouraging: Both the static susceptibility map and the real-time landslide hazard threat assessment identified El Cambray as having the highest possible threat levels. As more events occur and as regional partners continue to complete their own countries' landslide inventories, we will update the HRC landslide hazard threat assessment model parameters to reflect the most complete and accurate landslide threat assessment.

References

- Baum, R. L., and J. W. Godt (2009), Early warning of rainfall-induced shallow landslides and debris flows in the USA, *Landslides*, 7(3), 259–272.
- Georgakakos, K. P., R. Graham, R. Jubach, T. M. Modrick, E. Shamir, and J. A. Sperfrance (2013), Global flash flood guidance system, phase I, *HRC Tech. Rep.* 9, 134 pp., Hydrol. Res. Cent., San Diego, Calif.

Posner, A. J., and K. P. Georgakakos (2015a), Normalized landslide index method for susceptibility map development in El Salvador, *Nat. Hazards*, 79(3), 1825–1845.

Posner, A. J., and K. P. Georgakakos (2015b), Soil moisture and precipitation thresholds for real-time landslide prediction in El Salvador, *Landslides*, 12(6), 1179–1196.

Sepulveda, S. A., and D. N. Petley (2015), Regional trends and controlling factors of fatal landslides in Latin America and the Caribbean, *Nat. Hazards Earth Syst. Sci.*, 15, 1821–1833.

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Workshop on Scientific Exploration of Induced Seismicity and Stress (SEISMS)

Earthquakes, both natural and induced, remain unpredictable because direct observation of the basic processes that link parameters such as stress, pore pressure, and slip on a fault has proven difficult. This workshop, funded jointly by International Continental Scientific Drilling Program (ICDP) and the Southern California Earthquake Center (SCEC), will focus on earthquake science questions that could be addressed with fault zone boreholes in and around active faults, and will evaluate different strategies for making direct observations of earthquake rupture in the subsurface. Because it is difficult to predict when and where an earthquake will occur, we will discuss the possibility of inducing fault slip (an earthquake) and associated seismicity through fluid injection at an instrumented site suitable for scientific study. Such a discussion will also have a practical benefit for understanding the thresholds for induced seismicity. Topics to be discussed will be: i) building an observatory for near-source observations of earthquake processes; ii) establishing the physical and chemical effects of fluid injection into the subsurface on fault strength and earthquake source characteristics; and iii) investigating the impact of deformation caused by earthquakes on the subsurface physical environment.

The workshop will be held at Lamont-Doherty Earth Observatory from March 29–31, 2017. Limited partial and full travel funding is available. To apply, send a 2 page CV and a single page statement of interest to seisms@ldeo.columbia.edu. The statement should include your interest in the project and a summary of your expertise. The deadline for travel support application is January 6, 2017. Early career scientists are strongly encouraged to apply to help shape what will be a long-term project. For further information, please consult: <http://seisms.icdp-online.org>

TEX Program to Lead Climate Effort Launched by White House



Reuters Photographer / Reuters Pictures

In April 2001, the overflowing Mississippi River caused flooding in and around Dubuque, Iowa. During an early iteration of the Resilience Dialogues, Dubuque officials and residents explored questions about future flooding and other concerns.

The White House Office of Science and Technology Policy (OSTP) has announced the launch of the Resilience Dialogues, a collaborative effort to help local communities address climate-related vulnerabilities. The AGU Thriving Earth Exchange is spearheading the effort with its lead partner, the U.S. Global Change Research Program (USGCRP).

During the past 3 years, the Thriving Earth Exchange (TEX) has created a growing program that brings together communities facing challenges related to the geosciences, such as adapting to climate change and protecting water quality, and pro bono geoscientists who are experts in pertinent fields. TEX also connects the communities and their scientific partners with funding sources, expert networks, software, and other resources that help those communities implement solutions. The Resilience Dialogues will extend TEX's ability to connect AGU members with community leaders in ways that leverage Earth and space science to make local impacts.

Intended to address climate change specifically, the Resilience Dialogues approach

(see <http://bit.ly/rd-org>) helps community leaders identify, access, and tailor scientific information and expertise to solve or inform their unique local climate challenges. To

Resilience Dialogues will extend TEX's ability to connect AGU members with community leaders in ways that leverage Earth and space science to make local impacts.

help foster effective and productive communication among community leaders, scientists, and other facilitators with relevant skills and experience, the Resilience Dialogues service provides an extended online platform for open and ongoing discussion and in other ways encourages resilience-

focused dialogue among participants. It also gives access to a network of scientists and community leaders who can share real-world experience.

The success of programs like TEX inspired the collaborative approach of Resilience Dialogues. That's one of the reasons TEX was invited to help lead the Resilience Dialogues team assembled by OSTP.

TEX is partnering with six federal agencies and 10 other nonprofit organizations, private partners, and community-based resilience networks to tackle local problems. OSTP formally announced the program on 31 October in a rollout of three initiatives that address the growing issue of climate change (see <http://bit.ly/rd-announce>).

The Resilience Dialogues project is funded by a grant from the Kresge Foundation's Environment Program, which focuses on helping communities build resilience in the face of climate change.

Federal agency partners, led by the inter-agency USGCRP, include the following:

- Federal Emergency Management Agency
- National Oceanic and Atmospheric Administration
- U.S. Environmental Protection Agency
- U.S. Department of Agriculture
- U.S. Department of Energy
- U.S. Department of the Interior

The Resilience Dialogues leadership team includes the following nonprofit and private partners, in addition to TEX:

- American Association of Adaptation Professionals
- American Meteorological Society
- Institute for Sustainable Communities
- Meridian Institute
- Massachusetts Institute of Technology's Climate CoLab

To develop a service that community-based networks can use to advance their work with diverse communities, the Resilience Dialogues team is working closely with several resilience networks:

- Resilience AmeriCorps
- California Governor's Office of Planning and Research
- ICLEI—Local Governments for Sustainability
- Community and Regional Resilience Institute
- Southeast Florida Regional Climate Change Compact

By **Raj Pandya** (email: rpandya@agu.org), Program Director, Science, AGU

Earthquakes Could Funnel Radio Waves to Dark Zones in Mountains



Alpsdake

Just like visible light, radio waves leave shadows on the opposite sides of obstacles like mountains. Modeling based on the Tsurugidake peak in Japan, pictured here, shows that radio waves could still travel into these shadowed areas with the help of surface plasmons.

Similar to the way in which a mountain in the sunlight casts a shadow, large obstacles can create dark zones for radio waves. Unlike with visible light, though, scientists think radio waves could travel along the ground up a mountain peak and into the “shadowed” area, thanks to a natural phenomenon known as a surface plasmon. Because surface plasmons are related to underground stress, this could be used to help monitor seismic activity.

Surface plasmons, also called surface plasma waves, are products of electromagnetic waves moving over Earth’s surface. If positive electrical charges (similar to electrons but positively charged instead of negatively) can travel, they could interact with radio signals and flow to the tops of nearby mountains, oscillating in time with the radio waves. This collective oscillation is the surface plasmon, moving like a breeze over a lake.

Because surface plasmons need energy to oscillate, they can be induced only when the plasma frequencies of the surface electrical charges are higher than that of the radio wave passing by: The greater the difference between the plasma frequency and the radio wave frequency is, the stronger the surface plasmon is.

The positive charges necessary for a surface plasmon are released when rocks underground are subjected to stress. This seismic stress forces positive charge carriers to the surface, creating a plasma layer at the highest parts of the landscape. Because strong seismic activity corresponds to more tectonic stress and therefore more charge carriers (and thus a higher plasma frequency), there can be no surface plasmon without an earthquake. If there are enough of these positive charges on the ground’s surface, they could absorb and reradiate the energy from radio waves, causing them to randomly scatter from a mountain’s rough terrain.

In a new study, Fujii shows that when a surface plasmon is made up of a particularly high density of positive charges, it could propagate up over a mountain peak and down the other side, reradiating electromagnetic waves into the shadowed region of the mountain. Using both an ideal cone structure and a model of the Tsurugidake peak in Japan, the team’s supercomputer shows that surface plasmons scattered over surface bumps and mountain peaks. These peaks randomly reradiate incoming radio waves into a narrowly convergent, beam-like wave, focused on a small area.

The reradiated waves can reach areas that would have been inaccessible to the original signal. By monitoring these anomalous radio waves, researchers expect that scientists could monitor seismic activity over larger areas. (*Radio Science*, doi:10.1002/2016RS006068, 2016) —Leah Crane, Freelance Writer

Groundwater: A Hidden Influence on River Shape

From a single broad channel of rushing water to a braided network that's split into many narrow passages, rivers come in a variety of shapes and sizes. Scientists have shown that processes such as water flow, sediment transport, and vegetation all affect a river's shape. Here Bätz *et al.* show that one more phenomenon can be added to the list: groundwater behavior.

The link between groundwater behavior and a river's morphology is rooted in vegetation. Plants can slow erosion by rivers and assist river morphological evolution by trapping and stabilizing sediments. Thus, plant growth may limit a channel's dynamics and therefore its width. All in all, this has been defined as the capacity of plants to "engineer" their river systems.

But groundwater is necessary for vegetation to take root. So the team set out to test whether they could see a direct influence of groundwater behavior on changes in a river's geomorphic activity. They looked at a 2-kilometer reach of the Allondon River system, located west of Geneva, Switzerland. Historical aerial images allowed the team to reconstruct the morphological evolution of the reach and associated development of the vegetation cover over the past century. They compared these differences in morphological changes along the river to the dependence of vegetation growth rates (based on tree ring width measurements) on groundwater and river flow estimates.

The team showed that downstream, where the groundwater elevation is close to the surface and stable, vegetation quickly takes hold,

thus increasing channel stability via its "engineering" capacity. River channel width decreases. But upstream, where groundwater elevation is deep and variable, vegetation takes its time, causing the channel to remain unstable for longer and allowing for a more dynamic and wider channel.

Thus, the authors argue that groundwater variability has an important—and previously overlooked—role to play in a river's morphology. Understanding these complex, often hidden, connections underlying river behavior is crucial to promoting economically effective and environmentally friendly river reach and land management. (*Journal of Geophysical Research: Earth Surface*, doi:10.1002/2016JF004009, 2016) —Shannon Hall, Freelance Writer



Nico Bätz

New research shows that for rivers, like the Allondon in Switzerland, pictured here, groundwater can influence shape.

A New Model to Improve Gravity Models

Earth's gravity is shifting. As new lava flows breach the surface, the polar ice caps melt, and different patterns of drought and rain develop, the distribution of the mass of the planet—and therefore local gravity—is constantly changing. To help scientists better map these changes, NASA and the German Aerospace Center (DLR) launched the Gravity Recovery and Climate Experiment (GRACE) mission in March 2002.

GRACE consists of twin satellites that orbit Earth at a height of 500 kilometers, in tandem, 16 times a day. The probes fly roughly 200 kilometers apart, but that distance fluctuates as small changes in the planet's gravity push the two probes closer together or pull them apart. It's these minute variations that allow scientists to measure changes in the mass of Earth's surface.

To date, the mission has helped scientists better understand changes in groundwater, polar ice loss, vegetation coverage, atmospheric layers, and ocean dynamics in a warming world. In 2014, for example, the GRACE satellites helped demonstrate the true extent of the California drought. Scientists frequently use spherical harmonics, a set of mathematical functions that account for factors such as Earth's rotation and equatorial bulge, to create gravity models from GRACE data. However, this technique is prone to several errors. The anomaly maps, for example, show north-south stripes that later have to be removed.

At the Center for Space Research at the University of Texas at Austin, Save *et al.* created a more accurate gravity model without the need

for postprocessing procedures to remove noise. They used a different set of functions called mass concentration (mascon) blocks, which estimate anomalies within targeted grid locations. They divided Earth into a geodesic grid, which consisted of 40,950 hexagonal tiles and 12 pentagonal tiles, and estimated the mass anomaly—how much the mass of one block deviated from a long-term average mass of that block—for each. This provided them with a 14-year (and counting) time series of mass change for all the tiles over the entire Earth.

Mascon anomalies have been used for a few years now and can be applied at global scales, which means multiple fields of research—the study of water on land, in the world's oceans, and locked up in ice—can benefit from these models. However, the solutions presented here have an additional advantage: They are derived from GRACE data alone and don't require input from other geophysical models or data sources.

To test the new model's accuracy, the team compared it with independent ocean bottom pressure recorder data and estimates of ice mass loss from multiple studies. They found excellent agreement. Furthermore, because of the resolution of the traditional GRACE gravity models, the land hydrology and ice loss signals along the coast used to "leak" into the ocean. The researchers' new model shows little or no leakage of land signals into the ocean and may help scientists from many Earth science fields to improve their regional and global studies. (*Journal of Geophysical Research: Solid Earth*, doi:10.1002/2016JB013007, 2016) —Shannon Hall, Freelance Writer

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ATMOSPHERIC SCIENCES

Open-rank faculty position in Atmospheric and Oceanic Observations, University of Colorado, Boulder

The Department of Atmospheric and Oceanic Sciences (ATOC) at the University of Colorado, Boulder, invites applications for an open-rank faculty position for a person who plays a prominent role in the field of atmosphere, ocean, or cryosphere observations. Areas of interest include airborne, satellite and ground-based remote sensing, in situ observations, and land- and ocean-networks. The work should have broad applications to climate and weather, and should complement existing strengths within ATOC. This person should have a PhD in Atmospheric Science, Oceanography, or a related field, with a record of research and teaching excellence that meets the standards expected for appointment at an R1 doctoral university. Review of applications will begin 5 January 2017, and will continue until the position is filled. Informal inquiries can be made to Peter Pilewskie at peter.pilewskie@lasp.colorado.edu.

The University of Colorado is an Equal Opportunity/Affirmative Action employer. Applications are accepted electronically at <https://cu.taleo.net/careersection/2/jobdetail.ftl?job=06673&lan>.

Postdoctoral Research Associate

The Shepson Tropospheric Chemistry Research Group at Purdue University has an opening for a Postdoctoral Research Associate. The position involves an opportunity to lead, and to work on a number of other problems in atmospheric chemistry, including:

1. Aircraft-based methods for quantification of greenhouse gas fluxes
2. Nitrogen cycling in forest environments
3. Aerosol phase photochemistry
4. Arctic halogen chemistry and analytical mass spectrometry

Expertise in atmospheric/analytical chemistry, chemical instrumentation, and good computational skills is essential. The position is for one year, but potentially renewable annually. The position will be open until filled. Interested candidates should send a CV with a list of 3 references to:

Prof. Paul B. Shepson
Purdue University
560 Oval Dr.
West Lafayette, IN 47907
765-494-7441
pshepson@purdue.edu

Purdue University is an ADVANCE Institution. Purdue University is an EEO/AA employer fully committed to achieving a diverse work force. A background check will be required for employment in this position.

BIOGEOSCIENCES

Project Leader Positions in Climate Research, Pusan National University

The new IBS Center for Climate Physics (ICCP) at Pusan National University, Busan, South Korea, is seeking to recruit two Project Leaders in

1. Past-to-future transient climate modeling
 2. Tropical Climate Dynamics
- The successful applicants, with at least 6 years of postdoctoral experience, will lead and supervise a small research team (1–2 research fellows) to conduct innovative, cutting-edge research leading to high-impact publications in international refereed journals. The project leaders will closely interact with the ICCP director and other research groups within the center. Travel and workshop funds will be available and access to a new super-computer will be established in 2017/18.

Applicants should be emerging leaders in their field and have a PhD or equivalent in physical oceanography, atmospheric science, climate dynamics (or related). Applicants should have an outstanding publication record, a high level of independence and proven leadership skills and experience.

The positions are fixed term (initially 3 years) with possibility for renewal of up to ten years. The salary range will be: \$70,000–80,000 (including social benefits). The closing date for the application is December 31st, 2016.

Informal enquiries regarding further details of the positions can be made to

the Director of the ICCP, Prof. Axel Timmermann (axel@hawaii.edu), +1-808-9562720

The IBS Center for Climate Physics (ICCP) will be dedicated to advancing the understanding of natural climate variability, man-made climate change and their impacts on the hydrological cycle, regional processes, ice-sheets and sea level. The ICCP will be a research center of the Institute for Basic Science (IBS, <https://www.ibs.re.kr/eng.do>).

Application procedure:

Please submit a cover letter, statement of your research visions, curriculum vitae, the name of 5 references, and three publications to Ms. Ji Kim (jjkim0204@pusan.ac.kr).

EARTH AND SPACE SCIENCE INFORMATICS

Remote Sensing

ALABAMA, TUSCALOOSA 35487-0322. The University of Alabama, Department of Geography invites applications for a position in the area of Remote Sensing, starting August 16, 2017 at the rank of Professor with tenure. This new position will support the expansion of our Department and the initiation of our new Ph.D. program, tentatively scheduled to begin fall 2017. Successful candidates will demonstrate sustained accomplishments including a research program that is widely recognized and externally



COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

DEPARTMENT OF EARTH & ENVIRONMENTAL SCIENCES

Atmospheric Science Faculty Position

The Department of Earth and Environmental Sciences (DEES) of Columbia University seeks to fill a tenure-track Assistant Professor position in atmospheric science, broadly defined. The successful applicant is expected to develop a high-impact research program at Lamont-Doherty Earth Observatory (LDEO) focused on problems of global significance and to demonstrate strong potential for effective teaching at undergraduate and graduate levels. Applicants should submit a cover letter, CV, teaching and research statements, and name at least 3 references using our online site:

<https://academicjobs.columbia.edu/applicants/Central?quickFind=63610>

Review of applications will commence on December 19, 2016 and continue until the position is filled.

Columbia University is an Equal Opportunity/Affirmative Action employer, dedicated to fostering a culturally diverse and pluralistic teaching and research environment. We strongly encourage applications from women and members of underrepresented groups.

funded as well as a proven track record of graduate and undergraduate mentoring. It is expected that the candidate hired would significantly enhance the University of Alabama's visibility and impact in remote sensing research and scholarship. Preference will be given to candidates whose research complements the University's designation as a National Geospatial-Intelligence Agency Center of Academic Excellence in Geospatial Sciences and one or more of the department's broader research foci including: water resources, human-environment systems, environmental management and change, and human impacts on the environment (see <http://geography.ua.edu/>). A Ph.D. in Geography or closely related discipline is required.

The University of Alabama is rapidly growing (37,665 students) and provides excellent faculty support and many opportunities to collaborate with scientists on the Tuscaloosa campus, including the NOAA National Water Center <http://www.nws.noaa.gov/oh/nwc/>, and the new Alabama Water Institute and the Alabama Transportation Institute. This position is part of a University initiative to enhance its research productivity, and is one of two Full Professor appointments granted to the Department of Geography this year. Formal review of applications will begin February 6, 2017 and will continue until the positions are filled. Apply online at <http://facultyjobs.ua.edu/postings/39869>. Applicants must attach a cover letter, and CV (including contact information for at least three references). For additional information, contact Search Committee Chair, Matthew Therrell (therrell@ua.edu).

The University of Alabama is an Equal Employment/Equal Educational Opportunity Institution. All qualified applicants will receive consideration for employment without regard to race, color, religion, national origin, sex,

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"EEO is the Law" https://www1.eeoc.gov/employers/upload/eeoc_self_print_poster.pdf

GEOCHEMISTRY

Curator in Earth and Planetary Science, American Museum of Natural History

The Division of Physical Sciences of AMNH seeks to hire a tenure-track assistant curator in the Department of Earth and Planetary Sciences. We seek candidates who will bring petrological and geochemical methods to bear on problems related to planetary evolution. For example, candidates might integrate field, analytical, and theoretical studies of the rock record to provide insights into fundamental aspects of climate, environmental, and biogeochemical variability through time. The successful candidate will have demonstrated scientific creativity and the potential to build and sustain an innovative research program. They will be expected to take advantage of resources available at AMNH, which include world-class geological collections; a wide range of optical, electron beam, and x-ray analytical tools; experimental laboratories; LA-ICPMS facilities shared with Lamont Doherty Earth Observatory of Columbia University; and a program supporting scientific expeditions. They will oversee and expand the AMNH petrology collection. We welcome an intention and ability to collaborate with colleagues within AMNH and the regional community,

including Columbia University and CUNY, and to engage in AMNH's MA in Teaching of Earth Science and other education initiatives. Applications should include a cover letter; CV; research statement; statement addressing teaching, exhibition, and public outreach; PDFs of up to 5 publications; and three letters of reference. All materials should be submitted by December 16, 2016 to EPSsearch@amnh.org. Inquiries about the position should be directed to Denton Ebel (debel@amnh.org). The American Museum of Natural History is an EEO/AA Employer.

HYDROLOGY

Multiple Faculty Positions in Water Sciences, Hohai University

The College of Hydrology and Water Resources (CHWR) at Hohai University (HHU), China invites applications for multiple faculty positions in water sciences, to start as early as March 2017. The positions are open until filled. The salaries will be internationally competitive and commensurate with candidates' experience and skills.

Established in 1915, HHU is the leader of innovation and development of higher education in hydraulic engineering and water sciences in China. HHU has played as China's key force to solve its major water security issues. CHWR is a key component of HHU and is the first college established nationwide devoted solely to the study of water. The college is also key contributor of a national key laboratory and a national engineering center.

HHU is located at Nanjing, Jiangsu, China. Nanjing is the internationally recognized capital of Jiangsu province, one of the largest cities in China. Situated in the heartland of the Yangtze River Delta, it has long been a major center of culture, education, research, politics, economy, transport networks and tourism.

Positions:

(1) 2-3 Professors

CHWR seeks 2-3 faculty positions at the rank of full professor in the fields of water resources management, water resource policy, hydrometeorology, urban hydrology or water-food-energy nexus.

(2) 4-5 Associate Professors

CHWR also seeks 4-5 faculty positions at the rank of associate professor in the fields of water resources management, water resources policy, ecohydrology, urban hydrology, hydrometeorology, water informatics, and other fields of hydrological sciences.

(3) 2-3 Lecturers (Equivalent to Assistant Professors)

The study fields of the early-career faculties can span all above fields.

Primary Duties & Responsibilities

The successful candidates will teach and supervise students at all levels, while conducting independent, externally funded research programs in their fields of expertise. Support for

developing an active research agenda is provided through start-up funds and departmental support. CHWR will provide strong supports to the successful candidates to apply for national and provincial research grants and talent programs (e.g. Thousand Talents Plan and Thousand Youth Talents Plan).

Experience & Qualifications

All candidates must hold a Ph.D. in hydrology, water resources, and other related fields.

Senior candidates must be established leaders in their field with developed excellent research programs and demonstrate strong research and teaching experience.

Mid-career candidates should demonstrate strong records of publication and funded research, and participation in collaborations.

Early-career candidates with post-doctoral training are preferred and should demonstrate excellent academic credentials, strong research plan, and good ability to teach effectively.

Application Instructions

Applications should be submitted electronically as a single PDF file, and should include:

- A cover letter that addresses your interests, qualifications and experience;
- A curriculum vitae;
- A statement of research interests;
- A statement of teaching philosophy;
- A copy of undergraduate and graduate transcripts.

Three letters of recommendation should be sent separately as a PDF by the recommenders. Review of applications will begin upon receipt until the position is filled. Materials should be sent to: kzhang@hhu.edu.cn.

INTERDISCIPLINARY

Associate or Full Professor in Environmental Geosciences, Rensselaer Polytechnic Institute

The Department of Earth & Environmental Sciences at Rensselaer Polytechnic Institute invites applications for the position of Associate or Full Professor in Environmental Geosciences, with emphasis on individuals with research interests in the areas of environmental geochemistry, hydrogeology, environmental remote or local sensing, global climate science/modeling (paleo or future), environmental data analysis, or environmental field-imaging visualization.

The successful candidate will have duties that include teaching graduate and undergraduate courses in the Department of Earth & Environmental Sciences, fulfilling the duties of the Director of the Environmental Sciences undergraduate program, developing and maintaining robust programs of research and scholarship, and providing service to the department, the School of Science, and to Rensselaer.

Rensselaer has recently initiated several bold, new initiatives; the successful candidate should interface with one or more of these areas. Examples of

FACULTY POSITION IN SPACE SYSTEMS ENGINEERING



The School of Earth and Space Exploration (SESE) at Arizona State University invites applications for an **Assistant or Associate Professor** with expertise in space systems and technology, to begin August 2017.

Minimum Qualifications: experience in space systems and technology and a Ph.D. in a related discipline; evidence of scholarly contributions in space systems and technology; and a commitment to quality university teaching.

To apply, please submit to sesenewfac@asu.edu the following: 1) a cover letter; 2) a current CV; and 3) the contact information of three references.

<https://sease.asu.edu/about/opportunities/faculty-positions>.
Refer to Position #11737.

Initial deadline for complete applications is December 15, 2016.

Arizona State University is a VEVRAA Federal Contractor and an Equal Opportunity/Affirmative Action Employer. All qualified applicants will be considered without regard to race, color, sex, religion, national origin, disability, protected veteran status or any other basis protected by the law.
<http://www.asu.edu/aad/manuals/acd/acd401> <http://www.asu.edu/titleIX/>

The School of Earth & Space Exploration is an academic unit of the College of Liberal Arts and Sciences

SESE

these include the Rensselaer Institute for Data Exploration and Applications (IDEA; <http://idea.rpi.edu>), the Darrin Fresh Water Institute (DFWI), a comprehensive freshwater ecological field station and Institute-wide research effort that hosts The Jefferson Project at Lake George (<http://jeffersonproject.rpi.edu>). In addition, the Institute is conceptualizing a new, broader initiative that will bring together research and education activities in water, environment, ecology, and sustainability.

The successful candidate will have a PhD degree or foreign degree equivalent in geoscience or related discipline, along with the ability to demonstrate, through accomplishments achieved over a postgraduate academic career of seven or more years, an international reputation and record of excellence in scholarship, along with a sustained level of high quality educational activities including teaching and advising, and a significant level of professional service.

To apply, applicants must submit as single pdf document a curriculum vitae, a statement of research accomplishments and goals, a description of teaching interests, and a list of four professional references to: E&ES Faculty Search, Department of Earth and Environmental Sciences, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12180-3590; Email: spearf@rpi.edu (electronic submissions are preferred). Up to four select publications may be sent as separate files. Consideration of candidates will begin upon receipt of application. The nominal deadline for application is midnight, December 24th but recruiting will continue until the position is filled. Preliminary interviews will be conducted at GSA and AGU in Fall 2016.

We welcome candidates who will bring diverse intellectual, geographical, gender, and ethnic perspectives to Rensselaer's work and campus communities. Rensselaer Polytechnic Insti-

tute is an Affirmative Action/Equal Opportunity Employer.

BIOGEOCHEMISTRY, California State University, Fresno

The Dept of Earth & Environmental Sciences at California State University, Fresno seeks a broadly trained biogeochemist for a tenure-track assistant professor position in Biogeochemistry. Duties include teaching undergraduate and graduate level courses, mentoring students, conducting research in the area of expertise, and engaging in university service. Candidates are expected to demonstrate a commitment to or potential for teaching excellence, research, and scholarly activities, including successful grantsmanship and research publications.

Applicants must hold an earned Ph.D. in geology, geochemistry or a related earth sciences field. Further information about the position and how to apply can be found at <http://apptkr.com/914774>. Individuals must submit an on-line application, which includes attaching a letter of application, curriculum vitae, statements of teaching philosophy and research interests, and the names and contact information of five references.

For more information, please contact the search committee chair, Dr. Mathieu Richaud at mathieu@csufresno.edu. Information about the department can be found at <http://csufresno.edu/geology>. The position will remain open until filled. Full consideration will be given to those applications received by January 10, 2017. We encourage applications from minorities, women, and other under-represented groups. California State University, Fresno is an affirmative action/equal opportunity institution.

Economic Geology, University of Wyoming

The Department Geology and Geophysics at the University of Wyoming

invites applications for a tenure-track faculty position in Economic Geology at the Assistant Professor level. We define Economic Geology broadly, seeking applications from individuals whose research and teaching interests are focused on Earth material resources across a wide range of applications including, but not restricted to, emerging technologies and energy transitions. We are a research-active department seeking a colleague able to teach required courses in our degree programs as well as in their area of specialization. For information about our department and analytical facilities, please visit www.uwyo.edu/geolgeophys/ and select "Economic Geology Position".

The successful candidate must hold an earned doctoral degree in Geoscience or a closely related discipline by the position start date, have the demonstrated potential to develop a nationally competitive, externally funded research program, and have demonstrated teaching ability, with preference for individuals able to teach Economic Geology and Igneous & Metamorphic Petrology.

Applications must include: 1) a letter of application, 2) a curriculum vitae including a list of publications, 3) statements of research interests & teaching philosophy, and 4) contact information for at least three references. Do not include supplemental information such as off-prints of papers, reference letters, or transcripts.

Review of applications will begin Jan 20, 2017 and will continue until the position is filled. The preferred start date for the position is August 2017. To apply, contact: WYO_EG@uwyo.edu.

Faculty Position in Environmental and Water Resources Engineering (EWRE), Tufts University

The Department of Civil and Environmental Engineering at Tufts Uni-

versity seeks candidates for a tenure-track faculty position in the area of Environmental and Water Resources Engineering at the level of Assistant Professor. Exceptional candidates may also be considered for appointment at the rank of Associate Professor depending on experience and accomplishments. Candidates must possess a doctorate degree in hydrology, environmental engineering, water resources engineering, engineering systems, or a related interdisciplinary field.

We seek applicants with expertise in the area of hydrology and water resources, whose research interests relate to complex water challenges facing society—including but not limited to food-energy-water nexus, issues of scales and uncertainties, impacts of changing climate, and issues related to water resources access, allocation and management. Preference will be given to candidates with a proven record of scholarship and a focus on theory-practice synthesis. Principal responsibilities include the establishment of an externally-funded research program, graduate and undergraduate instruction and mentorship, and University and professional service. The successful candidate will join our Environmental and Water Resources Engineering program with strengths in hydrology, groundwater remediation, water quality modeling, water diplomacy, and contaminant fate and transport. The position offers considerable opportunity for collaboration in several interdisciplinary programs and organizations including Water: Systems, Science, and Society, Water Diplomacy, Tufts Institute of the Environment, and the Stockholm Environment Institute U.S. Office.

The Tufts School of Engineering (SOE) distinguishes itself by the interdisciplinary focus and integrative nature of its engineering education and research programs, within the intel-

Be inventive.

Looking for a postdoctoral or sabbatical research opportunity? The CIRES Visiting Fellows Program attracts scientists from around the world. Many postdoctoral fellows have gone on to careers at CIRES, NOAA, the University of Colorado Boulder, and other prestigious academic, government, and private institutions. We select visiting fellows who work on a wide range of environmental science topics, and we place great value on interdisciplinary research. Postdoctoral fellowships are for two years (\$62,000/year), and sabbatical fellowships are for up to one year. The application process opens in late October, and candidates are strongly encouraged to contact CIRES in advance of the January 9, 2017 deadline.

Program details and application: <http://bit.ly/CIRESvf>

Lindsay Chipman
Postdoctoral Visiting Fellow, Center for Limnology,
Cooperative Institute for Research in Environmental Sciences

Be Boulder.

 University of Colorado Boulder



tually rich environment of both a "Research 1" university and a top-ranked undergraduate institution. The past ten years have been a period of extraordinary growth for SOE at Tufts, with recruitment of over half of its current tenured and tenure-track faculty members and a more than three-fold increase in research productivity. Tufts offers the best of a liberal arts college atmosphere, coupled with the intellectual and technological resources of a major research university. Home to seven graduate and professional schools across three campuses, Tufts University prides itself on its culture of cross-school partnerships. Located on Tufts' Medford/Somerville campus, only six miles from historic downtown Boston, SOE faculty members have extensive opportunities for academic and industrial collaboration, as well as participation in the rich intellectual life of the region.

Questions about the position should be addressed to Professor Shafiqul Islam, search committee chair; Shafiqul.Islam@tufts.edu. Candidates should submit their application, including a cover letter, curriculum vitae, statement of research and teaching interests and objectives, and contact information for three references through Interfolio at <https://apply.interfolio.com/38646>. Review of applications will begin on December 1, 2016 and will continue until the posi-

tion is filled; applications submitted after December 1 are also welcome. Tufts University is an Affirmative Action/Equal Opportunity Employer. We are committed to increasing the diversity of our faculty, and thus, women and members of underrepresented groups are strongly encouraged to apply.

Faculty Position in Geophysics at the University of Houston

The Department of Earth and Atmospheric Sciences at the University of Houston invites applicants for a tenure-track faculty position in geophysics at the level of Assistant Professor or Associate Professor (untenured). The department is seeking outstanding candidates with the potential for exceptional research, excellence in teaching, and a clear commitment to enhancing the diversity of the faculty, graduate, and undergraduate student population. We seek candidates of outstanding ability in potential fields (gravity, magnetism, electricity, and electromagnetism), including data acquisition, processing, and interpretation, with research interests in near-surface, exploration, environmental, and solid-earth geophysics. Outstanding candidates will be considered from other fields of geophysics that build on department strengths, which include seismology, remote sensing, geodynamics, rock physics, and tectonics. The successful

candidate will participate with an enthusiastic team of geoscience faculty and students, in a department with a broad range of geophysical capabilities located in a vibrant city and one of the leading energy capitals of the world.

Information for Applicants

Candidates must have completed their PhD at the time of appointment. Successful candidates will be expected to build a vigorous, externally funded research program and demonstrate productivity via peer-reviewed publications. Candidates will also be expected to teach at both the undergraduate and graduate levels and will mentor MS and PhD students. We expect to fill the position by August 2017. Candidate evaluation will begin on December 1, 2016 and continue until the position is filled.

Candidates for the position should submit: 1) a letter of application including statements of teaching and research interests, 2) a curriculum vitae, 3) graduate student transcripts, and 4) names and contacts of at least three referees. Applications should be submitted electronically, via the university web portal: <http://jobs.uh.edu/postings/32813>.

Queries may be addressed to:
Dr. Hua-Wei Zhou, Chair,
Department of Earth and Atmospheric Sciences
University of Houston
hzhou@uh.edu

Further information can be obtained by viewing the departmental web page at <http://www.eas.uh.edu/> or by calling the department at (713) 743-3399.

The University of Houston is an Equal Opportunity/Affirmative Action Employer. Minorities, women, veterans, and persons with disabilities are encouraged to apply. The University of Houston is responsive to the needs of dual career couples.

Faculty positions at the Department of Geosciences, National Taiwan University

The Department of Geosciences at NTU is seeking active scientists to fill two faculty positions starting from August 1st, 2017. The positions are open to candidates from all fields in geosciences, but those who have strong background in the fields of mineralogy and petrology, geo-resources, stratigraphy, sedimentology, structural geology and hydro- and applied geology will receive more favorable consideration. Applicants are requested to submit the following documents: CV, list of publications, statements of teaching and research interests, names and contact information of three referees, and three to five articles published within the last seven years (one of which need to be designated as representative paper and must be published after August 1st, 2012). Application materials



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

EPFL's School of Architecture, Civil and Environmental Engineering (ENAC) invites applications for a Faculty position in the Institute of Environmental Engineering. Appointment at all levels (i.e. Tenure Track-, Associate-, and Full Professor) will be considered.

The Institute of Environmental Engineering currently covers a diverse portfolio of research and teaching in (non-exhaustive list): climate change adaptation, biogeochemical cycles, cryosphere, hydrology, hydrodynamics, limnology, precipitation, water quality, bioremediation, ecotoxicology, air quality, renewable energy, city and landscape monitoring/sustainability, ecology, and ecosystem dynamics. These research themes are underpinned by technical innovations and developments in, for example: remote and in situ sensing, field robotics (water, land, air), numerical modelling, as well as cutting-edge chemical, genomic, proteomic, and isotope analysis facilities. Our institute also hosts the newly established Swiss Polar Institute, which coordinates and supports research in Polar and other extreme environments, including the Alps.

In this context, we seek a candidate who can develop and lead an internationally recognized research program and strengthen our curriculum within the broadly defined area of Environmental Science and Engineering, complementing and integrating with existing groups. The successful candidate will be committed to excellence in undergraduate/graduate-level teaching as well as supervision of PhD students and postdocs.

EPFL offers internationally competitive start-up resources, salaries, and benefits.

With its main campus located in Lausanne, Switzerland, EPFL is a dynamically growing and wellfunded institution fostering excellence and diversity. It has a highly international campus at an exceptionally attractive location boasting first-class experimental and computational infrastructure. As a technical university covering essentially the entire palette of engineering and science, EPFL offers a fertile environment for research collaboration

Faculty Position in Environmental Science and Engineering at the Ecole polytechnique fédérale de Lausanne (EPFL)

between different disciplines. The EPFL environment is multi-lingual and multi-cultural, with English serving as a common interface.

To apply, please follow the application procedure on

<https://academicjobsonline.org/ajob/jobs/8558>

The following documents are requested in PDF format: cover letter including a statement of motivation, curriculum vitae, publications list, statement of research and teaching interests as well as the names and addresses, including emails, of at least three references (may be contacted at a later stage).

Screening will start on **February 1st, 2017** and the search will continue until the position is filled.

Further enquiries should be made to the Chair of the Search Committee:

Professor Anders Meibom

Director of the Environmental Engineering Institute
School of Architecture, Civil and Environmental
Engineering, EPFL-ENAC

E-mail: searchenvironmental@epfl.ch

For additional information on EPFL, please consult:

<http://www.epfl.ch> or <http://enac.epfl.ch>

EPFL aims to increase the presence of women amongst its faculty, and qualified female candidates are strongly encouraged to apply.

should be sent by email to Prof. J. Bruce H. Shyu, the Chair of the Searching Committee, at jbhs@ntu.edu.tw.

Deadline for application: January 15th, 2017. For more information, please refer to the website: <http://web.gl.ntu.edu.tw/>

Postdoctoral Fellowships

The Geophysical Laboratory, Carnegie Institution of Washington, invites applications for postdoctoral fellowships. The Geophysical Laboratory emphasizes interdisciplinary experimental and theoretical research in fields spanning geoscience, microbiology, chemistry, and physics. The Laboratory supports world-class facilities in high-pressure research; organic, stable isotope and biogeochemistry; mineral physics and petrology; and astrobiology.

Please visit <https://jobs.carnegiescience.edu/jobs/carnegie-fellowships-for-the-geophysical-laboratory-4/> to view a list of required materials and application instructions. Also, see <http://www.glcw.edu/> for a listing of personnel, current research interests, and major facilities.

Completed applications for Carnegie fellowships should be submitted by November 30, 2016.

The Geophysical Laboratory is located in Washington, DC, and is an equal opportunity employer.

Post-Doctoral Research Fellow – Remote sensing of West African savannas and grazing lands.

New Mexico State University seeks a post-doctoral researcher to join a collaborative team developing remote sensing-based applications relevant to natural resources and management of West African grazing lands and savannas. We seek a colleague with expertise in satellite remote sensing, geospatial analysis and programming, and a keen interest in capacity-building to advance adoption of remote sensing technologies for development impact. Position available starting January 2017 for one year, with annual renewal for an additional two years, subject satisfactory progress and continued funding. For more information, full position description and application procedures contact Niall Hanan (nhanan@nmsu.edu; use “SERVIR post-doc” as the subject field).

Post-Doctoral Research Fellow – Terrestrial and airborne LiDAR remote sensing of vegetation structure.

New Mexico State University seeks a post-doctoral researcher to lead a new initiative in terrestrial and airborne LiDAR remote sensing of vegetation structure in open woodlands and shrublands. We seek a colleague with a background in mathematics, physics or computer science and prior experience in collection and analysis of ter-

restrial laser scanner (TLS) and/or airborne LiDAR data. The scientist will develop advanced algorithms for 3-dimensional data analysis and retrieval of vegetation structural parameters. Position available starting January 2017 for one year, with annual renewal for an additional two years, subject satisfactory progress and continued funding. For more information, full position description and application procedures contact Niall Hanan (nhanan@nmsu.edu; use “Jornada post-doc” as the subject field).

Transportation Modeling, The University of Alabama

ALABAMA, TUSCALOOSA 35487-0322. The University of Alabama, Department of Geography invites applications for a position in the area of Transportation Modeling, starting August 16, 2017 at the rank of Professor with tenure. This new position will support the expansion of our Department and the initiation of our new Ph.D. program, tentatively scheduled to begin fall 2017. Successful candidates will demonstrate sustained accomplishments including a research program that is widely recognized and externally funded as well as a proven track record of graduate and undergraduate mentoring. It is expected that the candidate hired would significantly enhance the University of Alabama's visibility and impact in transportation research and scholarship. Preference

will be given to candidates whose research complements the University's designation as a National Geospatial-Intelligence Agency Center of Academic Excellence in Geospatial Sciences and one or more of the department's broader research foci including: water resources, human-environment systems, environmental management and change, and human impacts on the environment (see geography.ua.edu). A Ph.D. in Geography or closely related discipline is required.

The University of Alabama is rapidly growing (37,665 students) and provides excellent faculty support and many opportunities to collaborate with scientists on the Tuscaloosa campus, including the new Alabama Transportation Institute, Center for Advanced Public Safety, Alabama Center for Insurance Information and Research, and the Center for Advanced Vehicle Technologies. This position is part of a University initiative to enhance its research productivity, and is one of two Full Professor appointments granted to the department of Geography this year. Formal review of applications will begin February 6, 2017 and will continue until the positions are filled. Apply online at <https://facultyjobs.ua.edu/postings/39867>. Applicants must attach a cover letter, CV (including contact information for at least three references), and two separate statements of research and



POSTDOCTORAL RESEARCH AND VISITING RESEARCH SCIENTISTS ATMOSPHERIC AND OCEANIC SCIENCES PRINCETON UNIVERSITY/GFDL



In collaboration with NOAA's Geophysical Fluid Dynamics Laboratory (GFDL), the Atmospheric and Oceanic Sciences Program at Princeton University solicits applications to its Postdoctoral and Visiting Research Scientist Program.

The AOS Program and GFDL offer a stimulating environment with significant computational and intellectual resources in which to conduct collaborative or independent research. We primarily seek applications from recent Ph.D.s for postdoctoral positions but will accept applications from more experienced researchers. Applications from independent researchers and more senior scientists who may need partial support for sabbatical or short visits may also be considered. Postdoctoral or more senior appointments are initially for one year with the possibility of renewal for a second year based on satisfactory performance and continued funding. A competitive salary is offered commensurate with experience and qualifications.

We seek applications in all areas of the climate sciences. This includes research in basic processes in atmospheric and oceanic dynamics; climate dynamics, variability and prediction; atmospheric physics and chemistry; cloud dynamics and convection; boundary layer processes; land-sea-ice dynamics; continental hydrology and land processes; physical oceanography; ocean-atmosphere interaction; climate diagnostics and analysis. Applicants must have a Ph.D. in a relevant discipline.

Further information about the Program may be obtained from: <http://www.princeton.edu/aos/>. Applicants are strongly encouraged to contact potential hosts at GFDL and Princeton University prior to application to discuss areas of possible research.

Complete applications, including a CV, copies of recent publications, at least 3 letters of recommendation, and a titled research proposal should be submitted by January 15, 2017 for full consideration. Applicants should apply online to <http://jobs.princeton.edu>, Requisition #1600924. We encourage applications from women, under-represented minorities, veterans and those with disabilities. These positions are subject to the University's background check policy. Princeton University is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to age, race, color, religion, sex, sexual orientation, gender identity, or expression, national origin, disability status, protected veteran status, or any other characteristic protected by law.

teaching interests. For additional information, contact Search Committee Co-Chairs, Sagy Cohen (sagy.cohen@ua.edu) or Joe Weber (jweber2@ua.edu).

The University of Alabama is an Equal Employment/Equal Educational Opportunity Institution. All qualified applicants will receive consideration for employment without regard to race, color, religion, national origin, sex, sexual orientation, gender identity, gender expression, age, genetic information, disability, or protected veteran status, and will not be discriminated against because of their protected status. Applicants to and employees of this institution are protected under federal law from discrimination on several bases. Follow the link below to find out more.

"EEO is the Law" http://www1.eeoc.gov/employers/upload/eeoc_self_print_poster.pdf

OCEAN SCIENCE

ANTARCTIC OCEAN-ICE SHEET INTERACTIONS POSTDOC

The COSIM group seeks a postdoctoral researcher to study uncertainties in future sea level rise (SLR) due to the impact of changing oceanographic and atmospheric conditions on the Antarctic ice sheet evolution. The candidate will work with LANL staff members to develop an ensemble simulation approach to quantify

uncertainties in future Antarctic SLR. The ideal candidate will have a background in physical oceanography, an interest in ocean-ice interaction processes and uncertainty quantification, and strong computational skills. A doctorate degree in physical oceanography, climate science, atmospheric science, physics, or similar field completed in the last five years is required. Previous experience with running ROMS, CISM, or similar models is preferred.

In addition to applying on-line at <http://www.lanl.gov/careers/career-options/jobs/index.php>, interested candidates should send a curriculum vitae, digitized copies of transcripts, names and contact information of three references, and a cover letter detailing qualifications and research interests to Milena Veneziani (milena@lanl.gov) and Nathan Urban (nurban@lanl.gov). Review of applications will begin immediately and continue until December 15, 2016.

Candidates may be considered for a Director's Fellowship and outstanding candidates may be considered for the prestigious Marie Curie, Richard P. Feynman, J. Robert Oppenheimer, or Frederick Reines Fellowships. For general program information refer to the Postdoc Program web page <http://www.lanl.gov/careers/career-options/postdoctoral-research/index.php>.

EOE

Assistant/Associate/Full Professors - Physical and Biological Oceanography, Marine Geophysics/Geology, and Ocean Engineering

South University of Science and Technology of China



The school of oceanography at the South University of Science and Technology of China (SUSTC) invites applications for several tenure-track (or tenured) faculty positions at the ranks of Assistant, Associate, and Full Professor. Applicants must have earned Doctoral degrees in marine geophysics/geology, physical oceanography, biological oceanography, ocean engineering or closely related field. Successful applicants will be expected to establish a robust, externally funded research program and demonstrate a strong commitment to undergraduate and graduate teaching, student mentoring, and professional service. These positions will be open until filled.

SUSTC is a young university at Shenzhen in southern China since 2010 which is set to become a world-leading research university, to lead the higher education reform in China, to serve the needs of innovation-oriented national development and the needs of building Shenzhen into a modern, international and innovative metropolitan. These positions are created with a significant development to establish a vigorous research program in oceanography at SUSTC to serve the national call for China's important role in deep sea research and resource-oriented exploration in the world oceans.

To apply submit a cover letter, complete vitae with list of publications, and three names of references via <http://talent.sustc.edu.cn/en/>, or to Dr. Y. John Chen, Chair Professor at School of Oceanography, South University of Science and Technology of China, No 1088, Xueyuan Rd., Xili, Nanshan District, Shenzhen, Guangdong, China 518055.

International Faculty Cluster Hire in Geological Oceanography

The Department of Geological Oceanography (<http://dgo.xmu.edu.cn>) is expanding its international faculty with the addition of six (6) new positions planned for the second phase. Already one of China's top oceanography schools, the College (<http://coe.xmu.edu.cn:82>) aims to establish the Department of Geological Oceanography as a premier center in land-ocean interactions, sedimentary processes/records, and global change. The ranks of the appointments are open, and are commensurate with the applicants' qualifications and experience.

At this time, we seek highly qualified candidates in three complementary and synergistic areas of study:

Stratigraphy/Geophysics/Seafloor Imaging—Two (2) positions are available in the general area of seafloor imaging and subbottom profiling. Although all qualified candidates in this area will be considered, we are especially interested in candidates who apply state-of-the-art seagoing surface and/or subbottom mapping tools and analysis skills to the investigation of coastal and continental margin environments.

Sediment Transport Dynamics—Two (2) positions are available in the general area of observational sediment transport. We seek highly qualified candidates who use new and novel field approaches and tools to examine the flux and fate of terrestrial matter in and across continental margins, including rivers, estuaries, shelf and slope environments.

Numerical Modeling of Sediment Processes and Stratigraphy—Two (2) positions in numerical modeling are available in areas that support the observational program in land-ocean interaction and sedimentary records. Examples of areas that are of particular interest include, but are not limited

to: 3-D modeling of sediment transport and deposition/erosion, stratigraphic modeling, seabed diagenesis, surface processes/fluvial geomorphology.

We seek applicants with proven record or promise to contribute to the interdisciplinary research and teaching missions of the College. A Ph.D. degree is required at the time of appointment and in the case of a Chinese degree two years in an overseas postdoctoral position.

In conjunction with the State Key Laboratory of Marine Environmental Science (<http://mel.xmu.edu.cn/en/index.asp>), the College has access to state-of-the-art instrumentation and offers internationally competitive compensation, start-up and relocation packages. Special recruitment programs are available to exceptionally well-qualified candidates. Xiamen University recently launched a 3600-ton (78 m) research vessel and is completing construction of a marine station for cutting-edge education and research in oceanography. XMU envisions the development of a world-class program in Geological Oceanography with focus on interdisciplinary studies of sediment processes and the sedimentary record in China's diverse marginal seas.

Xiamen University, located along China's SE coast, was founded in 1921 with the vision to become the leading international university in China (http://www.xmu.edu.cn/en/about/xmu_at_a_glance). Xiamen University has inter-university cooperative ties with over 270 institutions of higher education at home and abroad, including the establishment of a new campus in Malaysia (<http://www.xmu.edu.my/a/5.html>).

To apply email a cover letter, CV, contact information for 3-5 references, and a statement of research and teaching philosophy and goals to Dr. Steven A. Kuehl, Interim Chair, Depart-

UF FLORIDA

The **University of Florida Water Institute** is seeking 6 highly motivated doctoral-degree students for Fellowships that provide an annual stipend, tuition waiver and health insurance for 4 years starting fall term 2017.

These PhD students will work collaboratively within an interdisciplinary team on a project that takes a systems approach to analysis of interbasin water transfer into the Tempisque River watershed in Costa Rica. This water transfer has altered hydrology, land use, community economic structure, and health of the downstream Palo Verde wetland.

Each student will develop a selected disciplinary expertise on the system while becoming well-rounded and knowledgeable in all other disciplinary aspects of the project. We will look especially for candidates eager to work across disciplines and willing to become proficient in Spanish.

Applicants should have a strong demonstrated interest in water issues and either a Master's degree in natural sciences, social sciences, or engineering, or a JD degree. Exceptional students with a Bachelor's degree plus research experience in an appropriate discipline will also be considered. Persons from groups under-represented in science and engineering professions are encouraged to apply. For more information and to apply for a Fellowship, go to http://waterinstitute.ufl.edu/WIGF/2017Cohort/Overview_2017.html.

ment of Geological Oceanography (kuehl@xmu.edu.cn). Applications will be considered beginning February 1, 2017, however the positions will remain open until filled.

Multiple Tenure-Track Positions in the Dept. of Atmospheric and Oceanic Sciences, School of Physics, Peking University

The Dept. of Atmospheric and Oceanic Sciences of Peking University invites applications for multiple tenure-track faculty positions in atmospheric and oceanic sciences. Two positions are available in physical oceanography, particularly in the areas of ocean general circulation and dynamics, air-sea interaction and climate, ocean biogeochemical cycle, ocean model development, and satellite oceanography. Four positions are available in atmospheric sciences, particularly in the areas of climate dynamics and modeling, synoptic and meso-scale meteorology, radiation and remote sensing, cloud physics, atmospheric boundary layer, land-air interaction, and planetary atmospheres. All positions are at the tenure-track assistant professor level under the "Young Qianren" or "Bairen" programs. For exceptional cases, a more senior starting position may be considered. Recruiting is conducted semi-annually (in spring and fall), until all positions are filled. The deadline for this round of recruiting is Feb 28, 2017.

For application qualifications, benefits, required materials, and contact information, visit <http://www.atmos.pku.edu.cn/channel.action?chnlid=30>.

Assistant-Associate Professor, Oregon State University

Assistant/Associate Professor with focus on Physical Oceanography. The College of Earth, Ocean, and Atmospheric Sciences at Oregon State University located in Corvallis, Oregon invites applications for a full-time (1.0 FTE) 12-month tenure-track position. We seek a faculty member with a research focus on remote sensing, large-scale and mesoscale ocean circulation, data assimilation, or related areas of physical oceanography. This position will teach and mentor undergraduate and graduate students; develop and maintain a vigorous, externally funded research program; and collaborate with colleagues. Requires: Ph.D. in ocean science or a closely related field by the start of employment; scholarly potential demonstrated by a record of peer-reviewed publications and a clearly defined research agenda; potential for an externally funded research program, demonstrated by independent formulation and articulation of compelling scientific goals and proposed methods; potential for teaching and mentoring, demonstrated by clarity of written and spoken scientific expression, ability to work within a team, and

commitment to scientific methods and discipline; oral and written English; commitment to educational equity and to advancing the participation of diverse groups and perspectives. For college information see: <http://ceas.oregonstate.edu> To apply submit CV, letter of interest, and statements online at <http://jobs.oregonstate.edu/postings/34814>. For full consideration, apply by 15 January 2017. Closing date: 15 February 2017.

Tenure-track Research Scientist, Woods Hole Oceanographic Institution

The Physical Oceanography Department at the Woods Hole Oceanographic Institution (<http://www.whoi.edu/main/PO>) invites applications for a tenure track position on our scientific staff. The successful candidate will join a collaborative group of scientists who address a wide range of fundamental problems in ocean and climate dynamics, as well as interdisciplinary research questions, using observations, modeling, theory, and laboratory experiments. World-class technical support personnel facilitate the use of a broad mix of traditional and innovative instruments and observational techniques to make measurements on all scales from microstructure up to global, and in all ocean domains including open-ocean and coastal regions at polar, temperate and tropical latitudes. We specifically

seek individuals with expertise in these areas: 1) coastal dynamics, 2) high-latitude processes, 3) decadal-scale climate variability, and 4) air-sea interaction. We seek a balance of observational, modeling, and theoretical approaches, as well as interdisciplinary scientists with interests in the interplay between ocean dynamics and biological or geochemical processes, or in the interaction of the ocean with the atmosphere, the land, and the cryosphere. We expect to hire at the Assistant Scientist level, but exceptional candidates at more senior levels will be considered.

Applicants should have a doctoral degree, postdoctoral experience, and a strong publication record. Scientific staff members are expected to develop independent, externally funded, and internationally recognized research programs. They also have the option of advising graduate students and teaching courses through the MIT/WHOI Joint Program in Oceanography and Oceanographic Engineering (<http://www.whoi.edu/jointprogram/>). Opportunities for interdisciplinary research exist through collaborations with colleagues in the other science departments, centers, and labs at WHOI (www.whoi.edu/main/departments-centers-labs; www.whoi.edu/main/ocean-institutes). Members of WHOI's Scientific Staff are expected to provide for their salaries from grants and contracts, but the Institution provides sal-

Senior-level leadership positions in satellite remote sensing for the Earth Dynamics Observatory at the University of Arizona



The University of Arizona seeks senior-level scientists and faculty members in satellite-based Earth remote sensing focused on leading scientific observation, modeling, and mission/instrument development. Candidates with expertise in any area of satellite-based remote sensing are encouraged to apply, but we are particularly interested in those specializing in the water cycle, carbon cycle, ocean, atmosphere, natural hazards, ice sheet/sea level dynamics, and global ecosystem-climate change interactions—areas in which societal need and science opportunity are largest.

The scientists will build on and leverage the University of Arizona's strengths in Earth and planetary remote sensing, including our recent hiring of multiple new faculty in atmospheric, vegetation, ice sheet, and comparative planetary remote sensing, and will have the opportunity to build a complementary research group with significant UA startup investment to pursue collaborative and ambitious new projects. Multiple hires may be made.

Candidates may seek appointments in one or more departments/colleges within the University of Arizona. The Earth Dynamics Observatory seeks faculty who promote diversity in research, education, and outreach, and who have experience with a variety of collaborative, teaching, and curricular perspectives. More information and details of application processes are available at www.geo.arizona.edu/edo2016/.

The University of Arizona is a committed Equal Opportunity/Affirmative Action Institution. Women, minorities, veterans, and individuals with disabilities are encouraged to apply.

ary support when no other funding is available, as well as significant internal funding opportunities for developing innovative research projects. Candidates hired at the junior level will receive an initial appointment for four years with salary guaranteed. Women and minority applicants are particularly encouraged to apply. WHOI is sensitive to the issues of dual career families and will work with applicants to address these. Our benefits include vacation time, flexible scheduling, family illness days, medical and dental plans, child care subsidy, and an employer contribution retirement plan.

WHOI is the largest private, non-profit oceanographic institution in the world, with staff and students numbering approximately 1,000. Its mission is to advance our understanding of the ocean and its interaction with the Earth system, and to communicate this understanding for the benefit of society. The Institution is located in Woods Hole, Massachusetts, a world-renowned center of excellence in marine, biomedical, and environmental science.

HOW TO APPLY:

Apply online; please visit <http://jobs.whoi.edu> and respond to Job Reference 16-11-06. Applications should

include, as a single pdf document, a cover letter, CV, 3-page research statement that clearly describes your research interests, names and contact information for four references, and copies of up to three relevant publications.

Applications should be submitted no later than 31 January 2016.

WHOI is an Affirmative Action/Equal Opportunity Employer, M/F/D/V/EOE; it is also a member of the New England Higher Education Recruitment Consortium (NEHERC).

SOLID EARTH GEOPHYSICS

Assistant Professor Geophysics, School of Earth & Space Exploration, Arizona State University

The School of Earth and Space Exploration (SESE) invites applications for an Assistant Professor with expertise in global geophysical processes. Anticipated start date is August 2017. We desire a candidate who (1) addresses fundamental questions in the dynamics, structure, and evolution of Earth and other planetary interiors, and (2) will work closely with existing geophysics faculty and has the ability to develop collaborations with other closely affiliated research programs in SESE

(for example, possibilities include astrobiology, geochemistry, petrology, planetary science, surface processes, tectonics, and volcanology). We are interested in individuals showing capacity to bridge research in deep and shallow processes. Examples include how deep interior processes relate to the evolution of the lithosphere or the fluid envelopes of Earth and other planets. SESE is particularly interested in candidates with a strong track record in geodynamics.

Minimum qualifications

Ph.D in Geophysics or related field by the time of appointment

Established publication track record in Earth (or Earth and planetary) interior research

Demonstrated expertise in geophysical methods aimed at understanding large-scale interior dynamical processes

Demonstrated potential to establish a vigorous, externally-funded research program Commitment to quality teaching at the graduate and undergraduate levels.

Desired Qualifications:

Research expertise as noted above

Demonstrated success meeting the educational needs of diverse student populations and/or engaging in scientific outreach to diverse communities.

SESE brings together Earth and space science into one school, break-

ing traditional disciplinary boundaries to investigate the biggest questions. SESE combines the strengths of science, engineering, and education, to set the stage for a new era of exploration. See <http://sesse.asu.edu> for more information, and <https://sesse.asu.edu/about/opportunities/faculty-positions>.

To apply, please submit the following materials as a single PDF file: 1) a cover letter that includes a description of the applicant's research and teaching interests and experience, and indicate the Job number 11791 in your letter; 2) a current CV; and 3) the names, email addresses, institution, title, and telephone numbers of three references. Email the PDF of these application materials to sesenewfac@asu.edu.

Initial deadline for receipt of complete applications is December 30, 2016; if not filled, reviews will continue weekly until search is closed. A background check is required for employment.

Arizona State University is a VEVRAA Federal Contractor and an Equal Opportunity/Affirmative Action Employer. All qualified applicants will be considered without regard to race, color, sex, religion, national origin, disability, protected veteran status or any other basis protected by the law. <http://www.asu.edu/aad/manuals/acd/acd401> <http://www.asu.edu/titleIX/>

Ocean Prediction Postdoctoral Positions Naval Research Laboratory, Stennis Space Center, MS



The Naval Research Laboratory is seeking postdoctoral researchers to push forward the frontiers of ocean forecasting. The work covers a wide scope of physics including surface waves, thermohaline circulation, nearshore circulation, and ocean/atmosphere coupling from global to nearshore scales. This challenging work includes processing and analysis of satellite and in water observations, construction of numerical model systems on high performance computing systems and assimilation for predicting the ocean environment. For a quick overview of some of the research work within the NRL oceanography division at Stennis Space Center, visit the web site:

<https://www7320.nrlssc.navy.mil/pubs.php>

Applicants must be a US citizen or permanent resident at time of application. Applications will be accepted until positions are filled. Please e-mail a resume and description of research interests:

Gregg Jacobs: gregg.jacobs@nrlssc.navy.mil

THE
UNIVERSITY
OF RHODE ISLAND

GRADUATE SCHOOL
OF OCEANOGRAPHY

TWO FACULTY POSITIONS IN OCEANOGRAPHY

The Graduate School of Oceanography at the University of Rhode Island (<http://www.gso.uri.edu>) invites applications for 2 tenure-track faculty members:

- 1). Assistant Professor specializing in Biological Oceanography (posting number F00012); and
- 2). Assistant Professor specializing in autonomous systems and data processing for ocean observation (posting number F00010).

Located on the water's edge at URI's Narragansett Bay Campus, GSO is the state's center for graduate marine education, research and outreach. The new hires will have access to the Marine Science Research Facilities, estuarine research on GSO small boats, and the unique opportunity to participate in the active sea-going community of GSO and the Ocean Exploration Trust utilizing platforms such as the R/V Endeavor and E/V Nautilus. The new faculty members will be expected to develop strong externally funded research programs, advise graduate students, and teach undergraduate and graduate courses.

Search will remain open until filled. First consideration will be given to applications received by January 17, 2017. Second consideration may be given to applications received by February 15, 2017. Applications received subsequent to second consideration date (February 15, 2017) may not be given full consideration. Visit <https://jobs.uri.edu> and search individual posting numbers to read full position descriptions, required and preferred qualifications, and application instructions. The University of Rhode Island is an AA/EOOD employer and values diversity.

Postcards from the Field

Hi, Everyone.

What's in an iceberg? We're sub-sampling ice in Svalbard for trace geo-chemical analysis. Not as easy as it sounds when the big icebergs keep rolling over! @markinthelab @jensclarke

—**Mark Hopwood**, GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany. Photo by Jennifer Clarke, GEOMAR

View more postcards at
<http://americangeophysicalunion.tumblr.com/tagged/postcards-from-the-field>.





JpGU–AGU Joint Meeting 2017

Makuhari Messe,
Chiba, Japan

Abstract Submissions Accepted: 6 January–16 February 2017
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